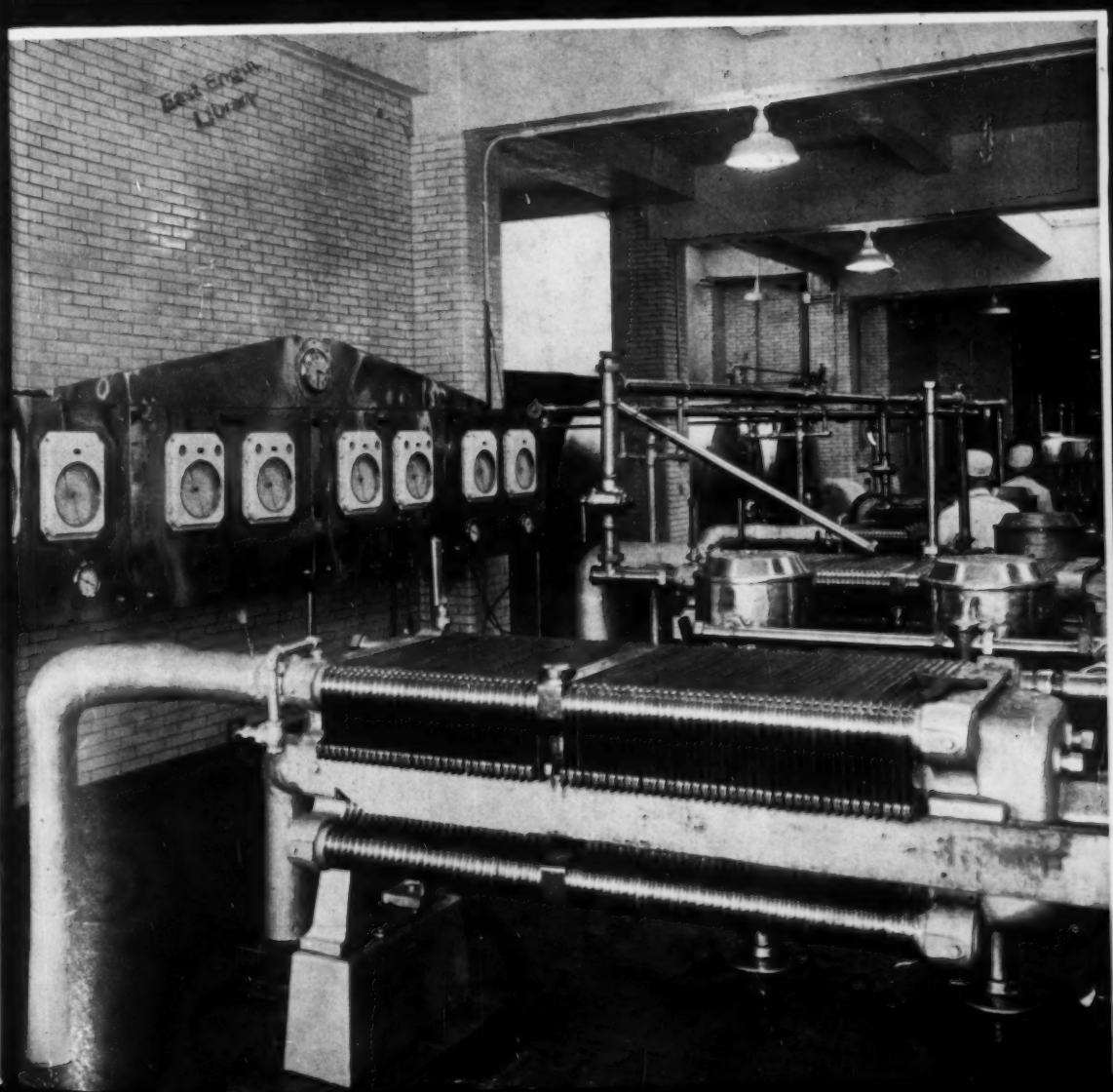
# INSTRUMENTS

## THE MAGAZINE OF MEASUREMENT and CONTROL



VOLUME 10

JANUARY 1937

NUMBER 1

# TAG Forges Ahead In 1937 With Notable Progress In Instrumentation!

Because of the contributions TAG has made in automatic control, practically every process industry operates more effectively today, with greater precision and less waste. More than 160 years of thermometer making live behind the TAGliabue name. Nearly half a century of service to industry sponsors its scores of indicating, recording and controlling instruments for temperature, pressure, flow and level.

These traditions and achievements in the past serve only as a spur for the future in anticipating and meeting industry's needs for increasingly effective instrumentation . . . For, more than ever before, American Industry today is a vast reservoir of unfilled wants in the making of profitable products and the manufacture of economical equipment and machines. As a primary function of all instrumentation, TAG recognizes this national opportunity and has geared its thinking, research and resourceful development energies to meet it.

We hope to merit, each month, your sustained interest in this page where we will show through 1937 the accredited and proved results of TAG's many new developments in the important phases of industrial instrumentation.

TAGLIABUE BROOKLYN N.Y. U.S.A.

# VISION MORE THAN DOUBLED

## —*for thermometers in your plant*

### *New Taylor Development in Tubing gives Thermometers two to five times greater visibility*

*Industrial executives prove amazing advantages of Taylor "BINOC" Tubing by test shown on opposite page.*

HERE'S a new idea in thermometer tubing.

Here's a radically different tubing in construction and results—an optically correct thermometer tubing. And what a difference it makes in readability and visibility!!!

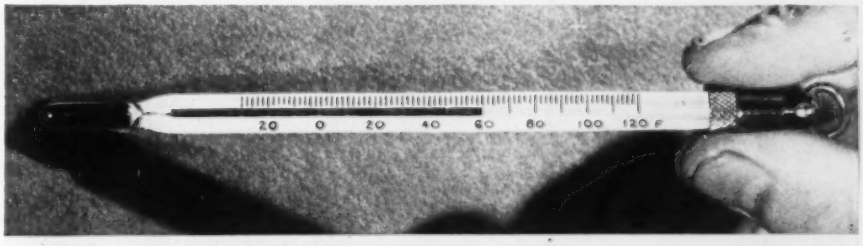
Probably never before have you realized the narrow angle of vision... the limited visibility of other thermometers now in use.

NEW TAYLOR "BINOC" TUBING DOUBLES THE ANGLE OF VISION THROUGH WHICH YOU CAN MAKE THERMOMETER READINGS. AND DOES IT WITHOUT SACRIFICING HIGH MAGNIFICATION. IT INCREASES THE VISIBILITY OF THERMOMETERS FROM TWO TO FIVE TIMES. IT GIVES YOU BINOCULAR VISION FOR THE FIRST TIME.

Add another important feature. Taylor "Binoc" Tubing eliminates bore reflection. Important to accuracy? You know that as well as we. There is a clear, definite contrast between the empty and the mercury-filled portions of the bore.

Naturally we are enthusiastic about this remarkable new development. But so are the plant executives, engineers, superintendents and equipment purchasers who have seen "BINOC." Editors of leading industrial magazines call it the greatest thing they've ever seen in thermometer tubing.

On the opposite page is a small instrument that a Taylor Representative will gladly bring to your plant so that you yourself can compare the present type lens tubing with "BINOC" Triple-lens Tubing. The test is simple. But it is very convincing. It shows what this advertisement has been talking about. A Taylor Representative will present the complete story. If you want quick action, write direct to Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada.




**TEST "BINOC" IN YOUR OWN THERMOMETER**

BE ONE of the first to get this New Taylor Engineer's Pocket Test Thermometer with "BINOC" Tubing. It is offered to you to make your own easy-reading tests. You'll find it convenient to use in scores of places. Range; 0° to 220° F. or −30° to 120° F. Fill out coupon and order the range you want. Send check or money order.

TAYLOR INSTRUMENT COMPANIES,
Dept. H-5, Industrial Sales, Rochester, N. Y.

I want to see "BINOC" Tubing. I enclose check for the Engineer's Pocket Test Thermometers (with protective case).

CHECK HERE
☐ WITH RANGE −30° to 120° F.—$1.25 EACH
☐ WITH RANGE 0° to 220° F.—$1.50 EACH

NAME_____

COMPANY AND TITLE_____

CITY_____ STATE_____

**Taylor**
INDUSTRIAL
THERMOMETERS
*with* "BINOC" *tubing*
REG. U. S. PAT. OFF.

# INSTRUMENTS The Magazine of MEASUREMENT and CONTROL


## CONTENTS · JANUARY 1937


Front Cover: Milk Plant Instrumentation
Borden's, Brooklyn, N. Y.
See description on page 1

Hardness and Hardness Measurements . . . 12
First article of a new serial
By S. R. Williams

Training Your Own Instrument Men . . . . 15
In a typical plant—3-year course
By A. G. Moon

Cathode-ray Tube Applications . . . . . 19
Radio apparatus testing
By R. R. Batcher

Oscillographs . . . . . 21
Electromagnetic class described this month
By Perry A. Borden and M. F. Béhar

*INSTRUMENTS'* READERS AT WORK
No. 21—Thomas Spooner
No. 22—P. A. Ferguson . . . . . 2

NEW INSTRUMENTS . . . . . 3
Indicators, recorders, controllers, inspection devices, etc., for the plant and laboratory

OTHER DEPARTMENTS, etc.

EDITORIAL COMMENT . . . . . 1
INSTRUMENTATION FORUM . . . . . 25
QUESTIONS & ANSWERS . . . . . 28
MANUFACTURERS' NEW LITERATURE . . . . 30
ADVERTISERS' INDEX . . . . . 30
BUYERS' GUIDE . . . . . A12





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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

## IN THIS ISSUE

A. G. Moon concludes his disclosures of "how we do it" by describing in detail how instrument service men are selected and trained at his plant (the name of which must remain secret—see editor's note in last issue).

This is the FOURTH article we have printed on training instrument men for industry. The preceding ones were:

1. Roy W. Brown (Firestone) Feb., 1932;
2. G. P. Bosomworth (Firestone) Nov., 1935;
3. R. C. Kennan (Brown Instrument Co.) Apr., 1936.

There will be more in *Instruments* and we fervently hope that other industrial publications will follow our lead, each promoting the training of men for its particular field.

Ralph Batcher's treatment of radio-testing applications of cathode-ray tubes is so comprehensive that we print only a few selected portions of it—portions of interest to all our readers.

Our "Electrical Measurements and Control" serial begins its fourth year with a continuation of the "Electromagnetic" section of the "Oscillography" chapter. At the end of this instalment—thanks to Perry Borden—there is a rather striking "exhibit."

This month sees the real beginning of our "Instrumentation Forum": the discussions and solutions of Problem No. 1 which appeared in November.

## THE FRONT COVER

is a photograph taken in the new plant of Borden's Farm Products at 90 Third Avenue, Brooklyn, N. Y. It shows the York plate-type continuous milk heaters, regenerators, and coolers, with the panel of Taylor recorders and controllers. Not shown in this photo is a Taylor control system which compensates for all load changes, especially regeneration losses when shifting from one holder to another.

# The "Hardness" Serial and its Author

IT may be said that hardness is the most important mechanical property and the least measurable, the most discussed and the least understood—hence the subject of controversies. These we shun. For example, three years ago when an article was submitted which began:

> Hardness testing machines, commercially available at present, do not measure hardness . . .

we accepted it but we printed, alongside, a declaration of neutrality:

> Our opinion is that it's all a question of definitions: if any body of men proclaims that hardness is "the diameter of a ball's impression," "the angle of pendulum rebound," "the force to produce a given impression" or what not, it is just that—as far as *that* body of men is concerned!

Though neutral, we like—for your sake—to print bold interpretations of facts usually dished out lukewarm. You will find the new serial vivid and authoritative, fascinating and informative. You will delight in the intellectual vigor of the distinguished author.

SAMUEL ROBINSON WILLIAMS graduated from Grinnell College (Ph.B. '01) and Nebraska University (M.A. '03), studied two years at the University of Berlin, devoted two years to research at the Physikalische Institut and at the Reichsanstalt, returned, obtained his Ph.D. at Columbia in 1906, and since then has combined physics teaching and research. Here is the way he put it in a hastily handwritten note:

> . . . a lot of fun on the side with what I am pleased to call research . . . thirty years on the subject of magnetism in which field I was constantly bumping into the property of hardness . . . [lately] playing with seven different machines and seeing if I can get sure-to-goodness readings with them. I am neither a metallurgist nor an engineer, just a second-rate physicist. . . .

This tantalizingly modest note did not mention his achievements, but these are a matter of record. He discovered the magnetic softening of steel. His publications number sixty-four, not counting two forthcoming books. His National Research Council work since 1918 has made history, and so will his serial, for Williams as a physicist has been cutting across the boundaries of metallurgy and mineralogy and seeing the subject of hardness from a generalized point of view. In thirty years he has not only seen the trees but he has been seeing—and mapping—the forest as a whole.

# INSTRUMENTS' READERS AT WORK

## No. 21—THOMAS SPOONER, Manager
## No. 22—PATRICK A. FERGUSON, In Charge of Standards
### Westinghouse Research Laboratories, East Pittsburgh, Pa.

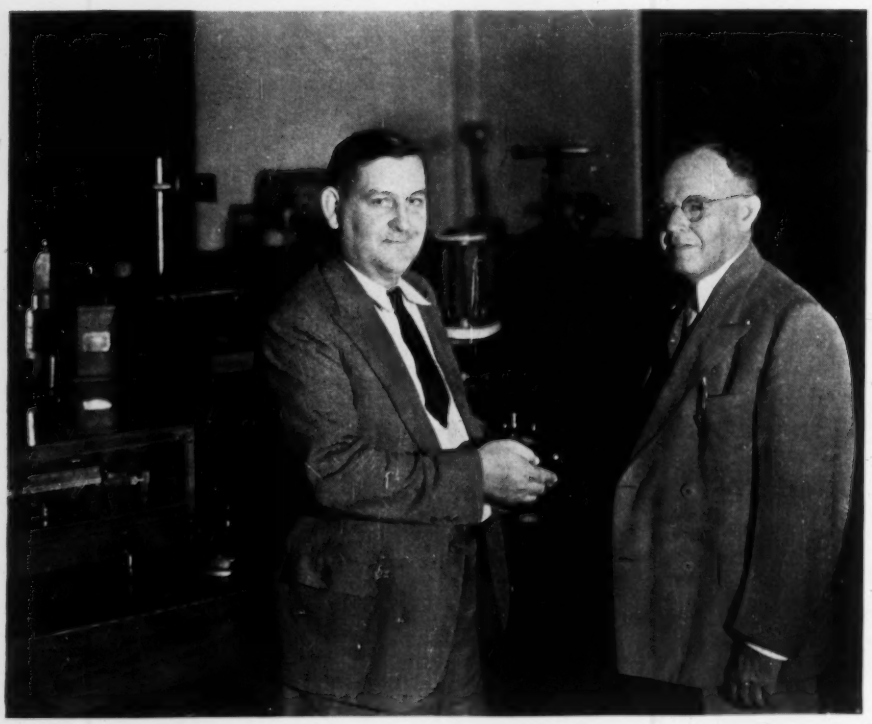
By M. F. BEHAR

IN No. 1 of this series, just a year ago, we introduced Charter Subscriber C. E. Fry and told how he and his twenty specially-trained calibrators serve all Westinghouse plants in the Pittsburgh district. We failed to make it clear that "The 2097 Important Instruments" listed on that page were related to *manufacturing,* and so we start 1937 by introducing the men behind the instruments related to Westinghouse *research.*

These men, too, are *Instruments* readers. In fact, the Manager of the great Westinghouse Research Laboratories is a charter subscriber to *Instruments,* a contributor to its columns and a member of its Editorial Advisory Board. And the head of the Standards Department has never missed a single issue, either! Therefore, we can go on with the Westinghouse instrumentation picture without stepping outside of *Instruments'* "family."

Born Jan. 1, 1884 at Whitefield, N. H., Spooner graduated from Bates College in 1905 and in 1909 he took his E.E. at M.I.T. That same year he joined Westinghouse Research—and has contributed to its progress ever since, his most notable achievements being in magnetic measurements, transformer losses, and kindred subjects. He has enriched technical literature through forty-odd papers and through his well-known book, "Properties and Testing of Magnetic Materials." Both the A.I.E.E. and the American Physical Society have raised him to the grade of Fellow. For many years he has been Chairman of the Magnetic Properties Committee of the A.S.T.M. And yet, at first, he refused to be photographed and written up for this page, modestly asserting that he no longer manipulated any instruments, being "only" the administrative head of the Laboratories! When, however, we pointed to the organization chart which shows that the Standards Department (among other "service groups") functions directly under him, he relented, insisting only that the picture should show Ferguson's Standards Room, with Ferguson in the center and himself "off to the side."

Which brings us to Ferguson—another veteran instrumentician: born in 1891 at Dunbar, Pa., he went to work in a Westinghouse plant at the age of fifteen. During most of these thirty-one years he has taken Westinghouse evening courses. Since 1914 he has been doing instrument standardizing work, and in 1928 he laid out the splendidly equipped Standards Room. The list of instruments on this page gives an idea of his responsibilities, which include not only the acceptance-testing and servicing of all these instruments used in the Research Laboratories, but the checking of all secondary standards used in all Westinghouse manufacturing plants in the Pittsburgh district.



LEFT—FERGUSON; RIGHT—SPOONER; SCENE—STANDARDS ROOM

SERVICE INSTRUMENTS—in hands of staff of Research Laboratories:

Portable a-c.—95 ammeters, 10 milliammeters, 3 microammeters, 73 voltmeters, 23 wattmeters, 4 frequency meters, 21 multimeters.

Portable d-c.—80 ammeters, 100 millivmmeters, 23 microammeters, 58 voltmeters, 15 millivoltmeters, 3 volt-ammeters, 3 multimeters.

Others card-indexed—30 potentiometers, 4 Wheatstone bridges, 6 comb'n ohm-volt-milliammeters, 4 capacity meters, 6 galvanometers, 12 ohmmeters, 6 standard mercurial thermometers, 8 optical pyrometers, 9 thermoelectric pyrometers, 5 Osiso portable oscillographs, 5 six-element oscillographs, 15 shunts.

INSTRUMENTS IN STANDARDS ROOM

(1) On shelves, for loan to various Divisions of Laboratories—approx. 120 portable secondary standards.

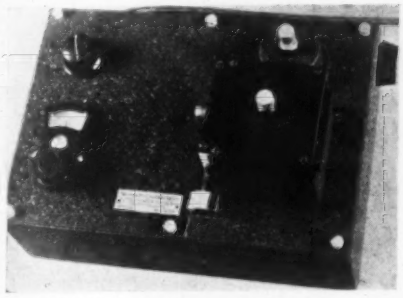
(2) Equipment of Standards Room—

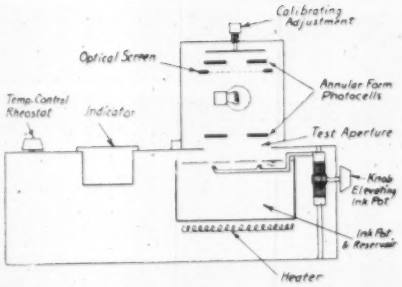
1 Standard potentiometer.
1 White double potentiometer and furnace for pyrometric standardizations.
25 Standard cells, some grouped in oil baths.
1 Carey-Foster bridge.
1 Kelvin double bridge.
3 Kelvin balances: 10 to 1000 amps.
6 Wall type galvanometers: graded sensitivities.
4 Standard resistors: 10 to 10,000 ohms.
2 Sets of standard shunts.
1 Thermal extensometric equipment.
1 Apparatus for calibrating optical pyrometers.
3 Standard thermocouples (NBS certif.) and stock of NBS tested wires.

# THE MONTH'S NEW INSTRUMENTS

## Paper Penetration Tester

Though constituting a new type of instrument for determination of the sizing in paper, using the inks which are actually used in printing or writing, the "News" Penetration Tester" nevertheless represents in some respects an extension of the methods followed in the flotation test and dry-indicator tests. It employs, however, a new objective method of measuring quantitatively the penetration of any medium into paper. Observations are made with dry-disk barrier-layer photoelectric cells arranged in a balanced photoelectric circuit in order to eliminate the optical characteristics of the surface of the paper such as color, texture and surface irregularities. Operation of instrument is based upon the change in reflectance of the surface of the sheet as the medium penetrates through from the under side. Cells react






to light reflected from the respective surfaces of the calibrating reference and of the test sample. An optical screen inserted into this balanced system decreases the illumination on the upper cell by a fixed amount; hence, balance is again reached only when an equal decrease in illumination on the lower cell has resulted from the penetration of the medium through the sheet. In making a test, the sample is placed over the test aperture and the photoelectric circuit balanced. The optical screen is inserted into the upper optical system and the ink is brought into contact with the paper. The time between the moment of contact of ink and paper, and the return of photoelectric balance, as shown by the indicator, is the measure of the rate of penetration. It is said that this instrument extends the value of present methods of measuring size: (1) by employing as the penetrating medium the same type of ink that is used in printing and writing; (2) by fixing precisely the end point of the test; (3) by permitting independent measurements to be made of the surface and beater size of a sheet. —*Barss, Knobel & Young, Inc., Kendall Square Bldg., Cambridge, Mass.*

**In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.**

**When writing to manufacturers directly, please mention this department as your source of information.**

**Or write to Information Section, Instruments Publishing Company.**

## Cathode-ray Oscillograph

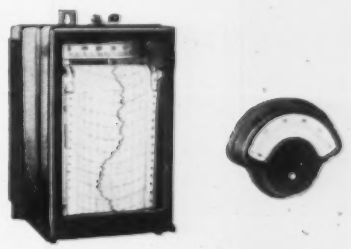
New "Type 156" Oscillograph with 5" cathode-ray tube has been designed for use in recording in connection with the moving-film camera or for observing slow-speed phenomena (below 10 cycles per second). When used for the first application, a cathode-ray tube giving a blue trace of high actinic value and extremely short persistance is used. The phenomenon is applied to one set of deflection plates and the moving film camera supplies the time axis. In the second application a DuMont cathode-ray tube with time delay screen is employed which will retain the wave on the screen for approx. 30 seconds. An external single sweep must be used when the unit is utilized for this type of work. There are of course numerous other applications beside these two. New unit consists of a high-voltage power supply, the anode voltage of which may be varied by means of a switch from 1500 to 3000 volts in 500-volt steps. At 1500 volts anode the voltage sensitivity is 75 d-c. volts per inch and at 3000 volts anode, 150 d-c. volts per inch. A Type 54-8-H DuMont cathode ray tube (of high-vacuum electron-lens focus type) with separate leads from each deflection plate, is mounted in the unit. A binding post strip at the rear of the unit allows direct connection to any of the deflection plates. This tube having an indirectly heated cathode, no filament ammeter or adjustment is necessary. Controls are provided for varying the brilliancy of the tube and focusing the spot. Unit is recommended in any application requiring a compact unit supplying high voltage to the cathode-ray tube and hence an unusually brilliant pattern. —*Allen B. DuMont Laboratories, Inc., Upper Montclair, N. J.*

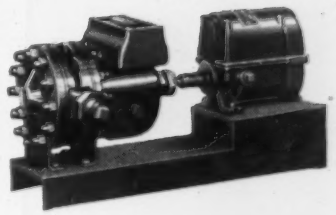
## Metal-clad Joints

Interchangeable ground-glass joints, precious-metal-clad to prevent mechanical and chemical freezing, have been developed. Silver, gold, platinum or palladium are used in sheathing the joints, forming a smooth, non-locking, vacuum-tight seal. Patents have been applied for. Any piece of Pyrex glass apparatus now equipped with interchangeable ground-glass joints may be purchased with metal-clad joints at a slight extra cost.—*Scientific Glass Apparatus Company, Bloomfield, N. J.*

## Fuel Meter for Furnace Combustion Control

Increasing use of heavy oils and tars as furnace fuels has intensified the demand first formulated in *Instruments*, Nov. 1932, pages 264-265: "demand for fluid meters with primary devices of positive types and secondary devices giving direct readings of rate-of-flow . . . a positive primary device measuring off isolated quantities, and a tachometric secondary. . . . Records of instantaneous values of the true volumetric rate : . . the tachometer reading is a perfect operating guide for controlling the process." Heretofore this demand has been met in many instances by home-made or home-assembled systems. New "Mir-o-meter" system consists entirely of standardized units, all of which (including optional accessories not shown in illustration) are commercially available.





Prefix "Mir" signifies functions of metering, indicating and recording. Metering is effected by a Bowser "Fig. 760 Registering Measure" for high-pressure high-temperature service (originally designed for hot asphalt, etc.), equipped with a 6-digit cyclometer register for quantity metering, and driving a tachometric d-c. generator. This energy consumption shortens the usually long flat portion of a displacement meter's registration curve, and therefore the $\frac{3}{4}$" size (standard for furnace applications) is recommended for flows not exceeding 10 g.p.m. (if cast-iron construction) or 8 g.p.m. (if bronze construction), and not less than 1 g.p.m. Operating temperature limits are 50 and 250° F. Viscocity limits for metered fuels are 400 and 10,000 sec. Sayholt Universal. A steam jacket is available for applications where fuel heating is desired. Flow-rate indicators and recorders are standardized electric tachometric units (see *Instruments*, Sept. 1931, pages 489-500) calibrated in g.p.m. when operating from standard generator. Indicator has a 7½" dial, is usually installed near furnace. Recorder, for installation in office, has indicating feature, takes strip charts with 5" scale width and may be equipped with chart drive for speeds of ¾, 1½, 3, 6 or 12 in./hr.—*S. F. Bowser & Co., Inc., Fort Wayne, Ind.*

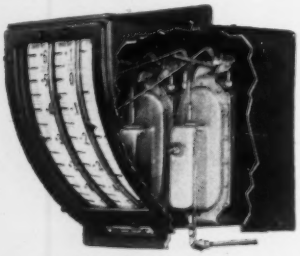
BAILEY METERS

# METERS and CONTROL *for Boiler Room Service . . .*

**Boiler Meters** Indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature. The use of this meter reduces fuel cost, lessens maintenance and outage, lowers standby costs, and adds capacity.

*Bailey Boiler Meter*

**Multi-Pointer Gages** for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



*Multi-Pointer Gage*

**Flow Meters.** For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

*Coal Meter*

**Granular Material Meters** For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

**Control Systems.** Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

*Complete Information on any of the above Bailey products will be gladly furnished upon request.*

G-7

**BAILEY METER COMPANY**

**1041 Ivanhoe Rd., Cleveland, Ohio**

## Portable Wheatstone Bridge

A newly redesigned self-contained Wheatstone bridge for measuring resistances from a fraction of an ohm to 9,999,999 ohms, suitable for shop, laboratory or field use, consists of a ratio dial, four rheostat dials, a pointer type galvanometer and a dry battery contained within a solid-walnut case measuring 9"x7"x6" high and having hinged lid, lock and leather carrying strap. Complete instrument weighs 10 lbs. Ratio dial affords seven decimal multipliers, from 0.001 to 1000. Ratio coils are accurate to 0.05%. Rheostat has a total resistance of 9999 ohms, variable in steps of 1 ohm. Each rheostat dial contains 9 coils affording smooth variation in resistance. Rheostat

coils are guaranteed accurate within 0.1%. Each dial has a positive clicking device, and only one value for each dial is exposed to view at any one time. The four rheostat dials may be used as a calibrated four-dial resistance standard, independently of the rest of the set. Extra binding posts permit use of external galvanometer and battery when desired.—*Rubicon Company, 29 No. Sixth St., Philadelphia, Penna.*

## Time Switches

New line of "Inter-Matic" Time Switches is made in two types: (1) "HC" unit, housed in moisture- and dust-proof drawn metal case, arranged for sealing mechanism with any of the standard type meter seals, designed for mounting on wall or in conduit. (2) "HS" type, with mechanism attached to a special mounting plate carrying switch-blade connectors which fit into the clip contacts of standard meter sockets. A case is not furnished because unit is to go in standard glass or metal meter housing. In both, the time dial, driven by low-speed, self-starting and self-lubricating motor, operates on a 24-hour cycle and is laid out in 15-minute divisions. The switch mechanism is actuated by adjustable "on" and "off" clips. One pair regularly provided; up to ten pairs can be applied. Minimum time between on and off and off and on operation is one hour. Clips operate a trip mechanism which controls a single-throw, double-break switch. Single- or double-pole switches are available. Switch contacts open and close with a snap action.

Wiping action on closing keeps the contact surfaces clean. Contact buttons are of silver. Rating is 35 amp. at 115 or 230 volts a.c. non-inductive load, or 1½ h.p. at 115 or 230 volts a.c. inductive load. Optional feature is manual control, whereby switch can be made to close the contacts permanently, to open them permanently, or to open and close them temporarily during any "on" and "off" period without affecting the clip setting. The manual control button can be left entirely within the case, or can be brought through to the outside for convenient operation. Overall dimensions of type HC: 7 3/16" × 5 3/4" × 3 5/16". Base plate of HS unit is 4 3/16" × 4 1/2" and overall depth 3 13/32" from face to back of the connectors. Weights are 3¾ and 3½ lbs. respectively.—*International Register Co., 15 Throop St., Chicago, Ill.*

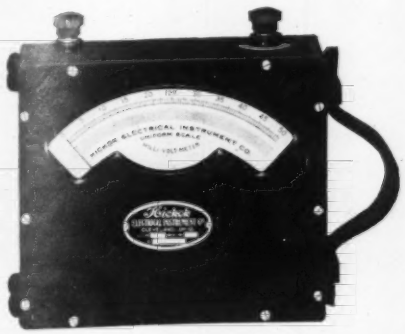
## Plug-in Resistors

Resistors of handy plug-in form and of selected values permitting various combinations for any total resistance are offered on the market after having orig-

inally been developed for use in resistance bridges and other test equipment employed in makers' own laboratory and plant. Housed in a standard 4-prong tube base, these units are available in values of 1 to 10,000 ohms. "Any accuracy up to 0.1%."—*Clarostat Mfg. Co., Inc., 285 No. Sixth St., Brooklyn, N. Y.*

## Dynamometer Type Portable A-c. Instruments

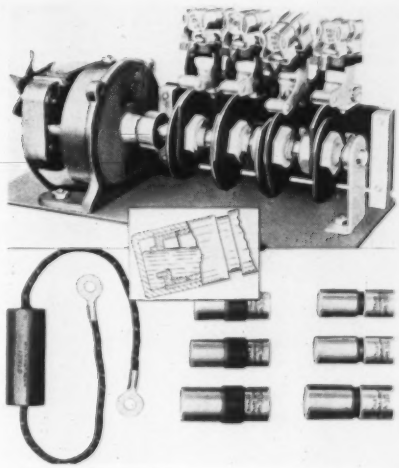
Designated as "Model 13," a new line of a-c. ammeters, milliammeters, voltmeters and wattmeters (single-phase only) has been brought out to meet demand for light portable testing instru-



ments having an accuracy of 0.5% and possessing such features as 5½" scale length, knife-edge pointers and mirror scales permitting accuracy of observations under field conditions. Accuracy guarantee is made possible by employment of the recently improved Hickok dynamometer movement (design same as, construction similar to, laboratory standards). Moving system is so damped, and torque is sufficiently high, so that instruments are suitable for severe field service. Instruments can be calibrated on d.c. by using regular laboratory potentiometer equipment and averaging two readings with reversed polarity to eliminate effects of stray magnetic fields. New line includes also (for extremely low voltage ranges and for self-contained high-current ranges) instruments having a magnetic vane movement. Ammeters can be supplied with pointer stops whereby exact value of starting current (as in motor testing) is indicated. Case is of molded Bakelite. Inside case is a low-carbon steel enclosure for movement, shielding against external magnetic fields. Instruments for ranges up to 300 volts or 300 amps. weigh 3½ lbs. and come in 3¼"×6¼"×7⅛" cases. The 300-750 volt instruments with built-in current transformers weigh 8 lbs. and come in 6" deep cases. *The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.*

## Time Cycle Controllers, and Metallic Mercury Switches

For controlling machine operations electrically by means of solenoids and magnets in definite timing sequence, two general types of time cycle controllers using new Staley Metallic Mercury Switches (see below) have been designed. "Model 611" Controller operates one or two circuits at the rate of 15, 30, 45 or 60 circuit makes and breaks per minute by means of a 110-volt, 60-cycle, shaded-pole induction motor rotating an adjustable cam and tilting the switch or switches by the use of a rocker arm. "Model 602" is designed to use from three to eight circuits and a separate camshaft which operates by pick-off gears. It is available in standard models having 1, 2, 3, 4, 5, 10, 15, 20 or 25 circuit makes and breaks per minute, timing sequence and time of circuit operation adjustable by means of the cams. Its base is cushioned on a base-plate to reduce noise of operation. Both controllers are equipped with Bakelite cams, terminal panels for motor and circuit connections, 15-amp. switches which, on a standard 110-volt non-inductive load circuit, have a capacity of 1650 watts. Either model can be supplied with a case. Models for operation on 220-volt circuits, synchronous or universal motors, special operating speeds between 5/11 and 60 makes and breaks per minute in the case of the Model 611 and speeds between 1/11 and 60 makes and breaks per minute in the Model 602, are available on special order.



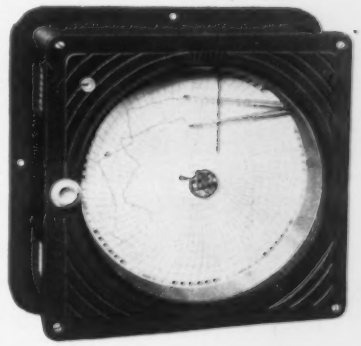
*Staley Metallic Mercury Switches* consist of a mercury-to-mercury make-and-break contact housed in a metallic envelope, hydrogen filled and with a patented seal to prevent gas leakage. A refractory material breaker localizes the point of circuit make and break and means are provided to insure quick operation by deionizing the arc at circuit interruption. Switch is normally installed in special clips similar to cartridge fuse clips, is cadmium plated after assembly; operates by tilting through an angle of approx. 10° from horizontal. Reversal of circuit function (make instead of break when one side is down in any specific design) is obtained by simply reversing the switch in its clips. It is said that the switches have low contact resistance and are free from breakage. Supplied in 5-, 10- and 15-ampere capacities and in various types including "Series 400" encased in fibre tubing and furnished with pig-tail terminals. A large number of mounting panels, bands and other accessories are available as standard parts to simplify attachment to machines.—*Electric Switch Corp., 1405 Union St., Columbus, Indiana.*

## Metal-tube Ballast Resistor Replacements

Another line of handy replacement parts consists of metal-tube voltage-dropping resistors, for which it is said that the requirements have been critically studied and reduced to the smallest number of different types to take care of the greatest variety of sets so equipped. A representative stock kit of twelve different types is said to be proving popular.—*Clarostat Mfg. Co., 285 N. Sixth St., Brooklyn, N. Y.*


ERIE BALTIMORE

# Gentlemen, Your Witness



- Every large Air conditioning installation is worthy of a witness of its performance.
- That witness should be an eye-witness, able to report directly, without computations or deductions.
  - The Friez Air conditions Recorder is just such an eye-witness. It reports directly temperature and humidity in per cent relative humidity. You do not need psychrometric tables or further figuring after you have read the chart. It knows and gives all the answers. In fact it is the only such eye-witness in the field of air conditions instruments.
- Such an accurate and reliable eye-witness returns the value of its fee many times in time-conserved and in efficient product control.

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# METALLIC BELLOWS *assemblies*

Hydron metallic bellows are used as control elements in temperature and pressure control devices, and for liquid or gas seals on compressors and pumps. They are formed from one-piece, thin wall, metal tubing of the highest grade, expressly developed for this purpose.

The bellows have exceptional life characteristics due to the automatic testing of the tube wall in our original patented hydraulic forming process, and to the freedom from rubbing of frictional tool engagement with the thin metal wall during the formative operation.

Increasing numbers of manufacturers find it more economical and more satisfactory to have us supply the complete bellows assemblies. We have the equipment and they are pleased with the results. Let us quote you on complete bellows assemblies for your products.

We are primarily manufacturers of bellows and bellows assemblies rather than completed devices incorporating same, with the obvious intent of avoiding any competitive situation between ourselves and our customers. We do, however, produce to our customers' specifications complete devices involving our bellows.

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**CLIFFORD MFG. CO.**

**564 East First Street Boston, Mass.**

FACTORY REPRESENTATIVES

Riley Engineering Corp., 1481 14th St., Detroit
Franklin G. Slagel, 923 East 3rd St., Los Angeles
J. J. Shriver, 221 North La Salle St., Chicago

## New "Clip-on" Models

The Clip-on Ammeter originally introduced some six years ago was at first only available in the standard 0-100/500 amp. combination. Additional low- and high-range combinations have recently been added to the line so that this instrument is now available in four standard low-range combinations and three high-range combinations, as follows:

*Low:*

0-10/50 amps.
0-15/75 amps.
0-20/100 amps.
0-50/250 amps.

*High:*

0-100/500 amps.
0-100/1000 amps.
0-200/1000 amps.

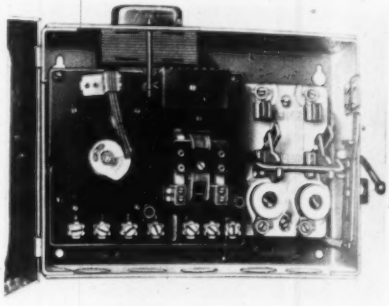
With these stock instruments it is possible to measure currents from 0.2 amp. up to 1000 amps. without opening the circuit or shutting down the equipment under test, or even removing insulation from the conductor concerned. All Clip-on Ammeters are supplied with fully insulated clips as well as Bakelite handles so that they can be used with equal safety on insulated or uninsulated conductors. *Ferranti Electric, Inc., 30 Rockefeller Plaza, New York, N. Y.*

## Dial Thermometers

New "Dura" dial thermometer is said to be "to the best of our knowledge the only dial thermometer with every part made of corrosion-resistant material." Bulb, socket and connecting tubing are all of 18-8 stainless steel. Tubing consists of capillary, spiral armor and closely-woven braid, further protected at case and bulb by additional reinforcements. Each part of this is stainless steel. Moisture- and dust-proof case is of corrosion-resistant phenol condensate, has shatter-proof glass front. Movement is of 18-8 stainless steel. Dial has a natural finish with deeply etched black figures. New thermometer may be used in measuring temperatures from —40 to 1000°F. and for distances up to 100 ft. from point of measurement. Pointer has micrometer adjustment permitting field adjustment without removing dial. Thermal system is mercury-filled, all welds are made by atomic hydrogen method and every pressure-spring is tested to 2½ times working pressure and aged by 1500 flexures. —*American Schaeffer & Budenberg Div., Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.*

## Stoker Controllers

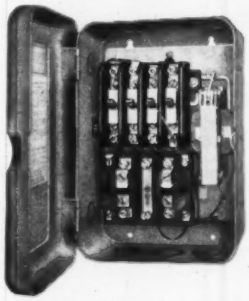
Features embodied in new "5" line of stoker combustion controllers include a trip-free bimetal overload protective unit, built-in knife switch and fuse receptacle, synchronous electric time-cycle cam for maintaining proper combustion



at all times, pilot relay and transformer for supplying low-voltage current to the thermostat circuit. The bimetal overload unit, incorporated in new Types 554 and 556, gives positive motor protection against overload from any cause, is designed to give uniform operation throughout the life of the control without the replacement of parts, is equipped with a trip-free reset button (maker's exclusive feature) which makes it impossible to block the contacts closed, eliminating any chance of running the stoker motor without overload protection, is wired into the internal circuit of the controller and does not change external wiring in any way. Types 552 and 554 incorporate the knife switch and fuse receptacle in the controller case, further simplifying installation and wiring on the job. Illustration shows Type 554-2P. Time cycle cam is in center of, bimetal overload unit at upper right of, control panel. All of these new stoker controls are rated >½ h.p. 110-volt 50- or 60-cycle as standard, and are available for ½ h.p. 220-volt service, and for odd cycle service in either 110 or 220 volts when specified. Thermostat circuit with all controls is 25 volts.—*Penn Electric Switch Co., Des Moines, Iowa.*

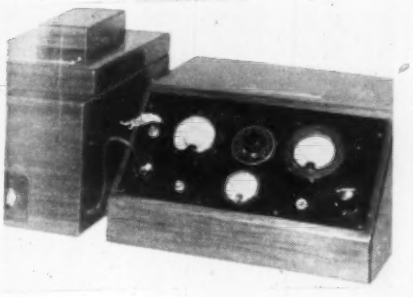
## Magnetic Starters, Contactors

A new line of magnetic starters and contactors, known as "Type C.M." for 1½ to 25 h-p. single or polyphase motors, employ the self-cleaning, self-aligning "wiping" contact action, with all parts assembled on a non-carbonizing heavy black glazed porcelain base. The complete mechanism of both devices, being mounted on a steel backplate, is entirely removable for wiring by loosening three screws. Relay heaters, ½ to 80 amps., are interchangeable with one another on all sizes of "C.M." starters.—*The Trumbull Electric Mfg. Co., Plainville, Conn.*



## Paper Formation Tester

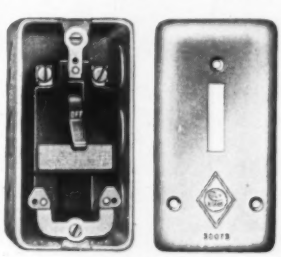
Employing a photoelectric cell to substitute objective measurement for human estimates, a new instrument determines the quality of a formed sheet of paper known as formation. Mill processes can thus be adjusted so that proper formation or con-



struction is obtained. The sample to be measured is moved at high velocity between a steady light source and the photocell. Variations in opacity of paper, due to variation in either thickness or structure, cause fluctuations in photocell current. These are amplified to deflect a pointer, while the average steady photocell current is indicated on a second dial. The ratio of the readings of the two indicators gives the formation number. For additional convenience provision is made for adjusting the steady current component to the same value for every sample to be tested, making the reading of the output meter alone the formation number. Indicators and controls are mounted on an inclined panel for convenience in reading from either a sitting or standing position.—*Thwing-Albert Instrument Co., 3339 Lancashire Ave., Philadelphia, Pa.*

## Auxiliary Circuit Breaker

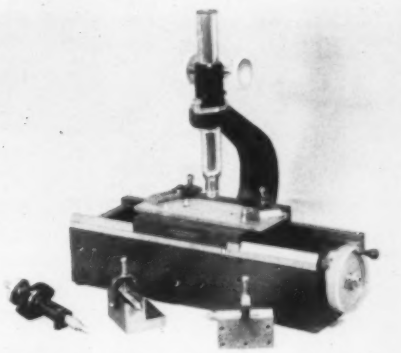
Increasing demand for a simple, compact auxiliary circuit breaker for standard mounting is said to be met by new "yoke-mounted Protectit," designed to be mounted in standard metal wall boxes as well as in special metal cabinets for surface mounting. Two types



are available, a fixed capacity device, made in ten differently rated sizes, and the interchangeable-heater-element type for which there are twenty heater elements all with different ratings. Both Protectits have a maximum voltage rating of 250 volts a.c. or d.c. and a maximum horsepower rating of 1 h.p. and are listed as such by Underwriters' Laboratories.—*Colt's Patent Fire Arms Mfg. Co., 17 Van Dyke Ave., Hartford, Conn.*

## Universal Measuring Engine

Simple or fairly complex measurements can be made with this new 20-cm. universal measuring engine. With basic equipment (including simple carriage and microscope) lengths measurements can be made on opaque objects less than 8" long to an accuracy of 0.0001" and on transparent objects less than 4". A series of tapped holes at 2" intervals



permits mounting various accessories both front and back. Microscope arm is separable, can be mounted in various positions. Two or more microscopes can be mounted, or a microscope and ruling attachment side by side. Provision is made for illuminating spectrum plates, etc., through one end of bed. Chief accessory, cross carriage, converts basic equipment into two-coordinate machine of 8" × 2" range accurate to 0.0001". Addition of marking punch converts device into 8" × 2" laying-out machine. Holders for dial gages, etc., permit production checking of tapers. Vee blocks and centers provide means for holding screws, etc.—*Mico Instrument Co., Cambridge, Mass.*

## Portable Gas-analysis Recorders

A portable line of "Ranarex" gas analyzers, employing the specific-weight principle (see *Instruments*, Nov. 1931, page 623) is announced, in models designed for determining (1) $CO_2$ content of boiler flue gases, (2) $CO_2$ content of furnace atmospheres, (3) air-fuel ratio in exhaust gases of internal-combustion engines, (4) specific gravity of natural or manufactured gas. As in previous "Ranarex" instruments, variations in barometric pressure, humidity, temperature or fan speed are compensated for by torque-balance mechanical principle. In models for use on internal combustion engines a vacuum or combined vacuum and pressure gage is built into instrument to permit measurement of pressure in intake manifold. Recorder can be furnished to operate either on lighting circuits or on standard 6-volt automobile batteries.—*The Permutit Co., 330 W. 42nd St., N. Y. City.*

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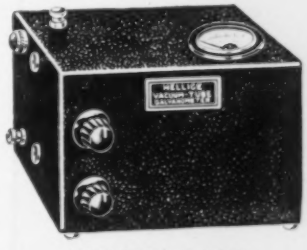
## GLASS ELECTRODE
# pH-METER

**READING DIRECT FROM 0 TO 14 pH**

*For All Types of Electrode Systems*

The new Hellige glass electrode pH-Meter measures hydrogen ion concentrations and reads direct in pH units with all types of electrode systems, over the complete range of 0 to 14. The sensitivity is 0.02 pH and the working accuracy is 0.05 pH. Rugged — Portable — Applicable for titrations and as a separate null indicator.



**VACUUM-TUBE GALVANOMETER**

This instrument is a general purpose null indicator of universal adaptability for precise measurements of oxidation-reduction potentials, streaming potentials, insulation resistance, and various types of bridge measurements.

Suitable for measuring systems of high resistance ($10^{19}$ ohms), and those easily polarized, with the same high sensitivity (0.1 millivolt) and the same simple technique as that of ordinary systems.

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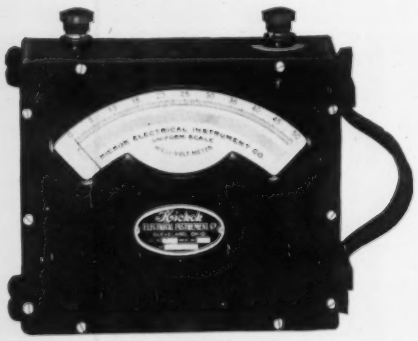
PORTABLES

A. C. AND D. C. ALL RANGES, ALL TYPES

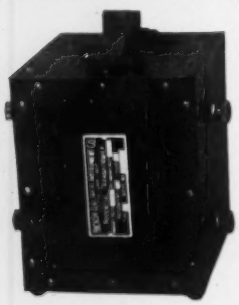
In acid-proof, moisture-proof, shock-proof, molded insulating cases.

UNIFORM SCALES, Knife-edge pointers, Anti-parallax mirrors.

Movements supplied ASTATIC, Shielded, or Un-shielded. ASTATIC portables, illustrated above, regularly supplied with guaranteed accuracy of 1/5 of 1% on A.C. or D.C.



Made open face, or with hinged, closing covers. Illustrated above is Model 18, accuracy 1/2%.



Also portable precision testing equipment; transformers, shunts, multipliers, power analyzers, etc. . . . All backed by thirty years experience in the manufacture of laboratory grade electrical instruments.

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Electrical Instrument Company

10514 Dupont Ave. Cleveland, Ohio

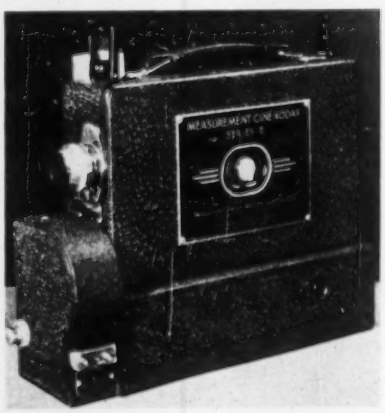
## Modulation Monitor

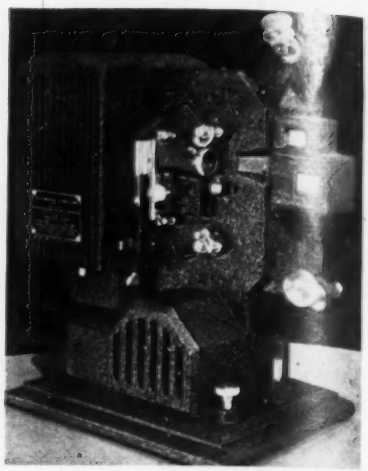
Model 1295 Master Modulation Monitor is said to eliminate uncertainty of depending on ear, variation of antenna ammeter or loop and light to determine

carrier shift and modulation percentage of voice-transmitting radio stations. Modulation of transmitters is shown on direct-reading dial of instrument, which has ranges from 40 to 120%, all readings in peaks. Visual information is provided on a second scale for carrier reference level for modulation test and also to check carrier shift during modulation. Adjustment of the transmitter can be regulated to prevent monkey chatter, cross talk and B. C. L. interference. Instrument is factory calibrated; no further calibration is needed. Case is metal with black wrinkle finish 7⅞" × 6⅝" × 4⅝".—*The Triplett Electrical Instrument Co., 3212 Harmon Drive, Bluffton, Ohio.*

## Improved Motion-study Camera and Projector

As a result of several years' experience with the closed-loop system of taking and projecting motion pictures, a new camera and a new projector have been developed. In the camera, a stronger motor has been installed and the lens permits a wider range of diaphragm stops and focusing settings. The extension cord has been made detachable and in addition there is supplied with the set an attachment which permits the recording of large images of small objects and movements. The projector lamp has been increased from 100 to 300 watts and the original perforated grid used for a safety shutter has been replaced with gold-

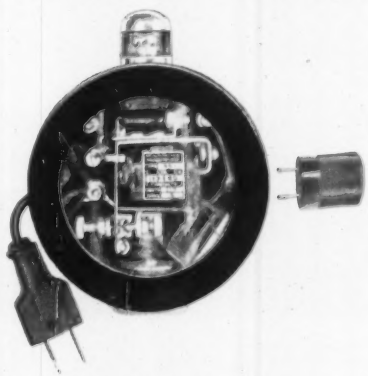




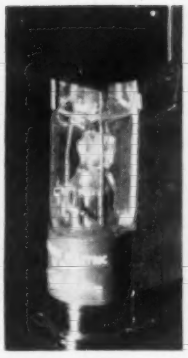
plated mica in order that clearer and more brilliant still pictures may be shown. For the analysis of film, frame by frame, a knurled knob has been permanently attached to the outside of the projector and replaces the detachable crank attached to the upper sprocket shaft in the original set. Complete equipment consists of motor-driven, governor-controlled camera, projector, number plate (for identifying activity), loop stand, loop winder, splicer, desk screen which folds flat, wall screen and (for use where normal lighting is insufficient) Mazda Photoflood lamp reflector. Special 8-mm. film is used, available in 25-ft. and 100-ft. rolls.—*Production Control Machines Corp., Chrysler Bldg., N. Y. City*

## Portable Relay Set

This new instrument is a ready-for-use self-contained relay set with attached cord. Relay proper is of type with dual contacts normally open and normally closed: power receptacle can be connected to either of the points to have contacts close or open when instrument (connected to right-hand plug) closes the coil circuit. Relay requires 2 milliamps. at 110-volt 60-cycle. Case is black Bakelite, 4¼" diam. and 2" deep, with "non-breakable glass" window. Top of



case carries toggle switch mounted directly behind pilot light which shows in illustration, together with a key-slot hanger for wall mounting. At left side of case there is furnished a 5-ft. Latex extension cord with rubber plug; at right side a special receptacle with its plug; at bottom a standard receptacle for plugging any load not exceeding 5 amps. at 110 volts a.c.—*H. B. Instrument Co., 2518 No. Broad St., Philadelphia, Penna.*

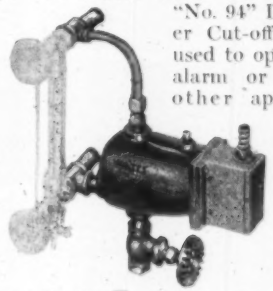


## Cathode-ray Tubes

Representing latest applications of electron-lens focusing principle, two series of cathode-ray tubes, all of the high-vacuum electrostatically-focused type, embody also some entirely novel ideas. For example, a unique double basing method permits the leads of widely different operating potentials to be segregated (so that higher voltages may be applied for photographing transients) and still retain the plug-in feature: an insulating sleeve encircling the neck of the tube some distance from the end (see Fig. 2) carries the contact plugs for the final anode and all deflection plate terminals. Use of tubes for important tests is possible by reason of linearity of deflections, fine focusing at all points on screen, and negligible distortion. "Type 325" series tubes have 4½" nominal diameter screens and are 16½" long overall; "Type 326," 7" screen and 22" length. Essential characteristics: filament 5 volts at 0.55 amp.; max. anode voltage 5000, focusing potential from 20% to 30% of anode voltage; modulation bias required is from 1.2% to 2% of anode voltage. Three types of screen are available, denoted by suffix to type number: "A" normal decay period, with greenish spot; "B" slow decay, light green; "C" fast decay, blue spot, for photographic use.—*Western Electric Co., 195 Broadway, N. Y. City; distributed by Graybar organization.*

## Low-water Cut-off or Alarm

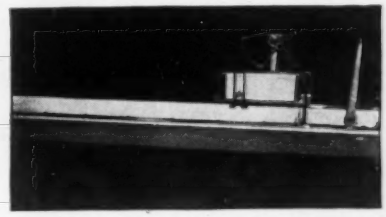
Principal application of this new float switch is to cut off automatically-fired unit on a heating boiler when water drops below safe level. Alternatively, "No. 94" Low-water Cut-off can be used to operate an alarm or in any other application



where a float control is to make or break a contact. Vital parts are all of corrosion resistant materials. Flexible bronze bellows seal. Inspectors can expose all electrical parts by removing switch cover. Capacity ½ h-p, 110-220 volts a.c. Working pressure 15 lbs./in.² Length 9" overall, width 3". Gage cocks and gage glass not furnished.—*Watts Regulator Co., 712 Lowell St., Lawrence, Mass.*

## Asphalt Tester

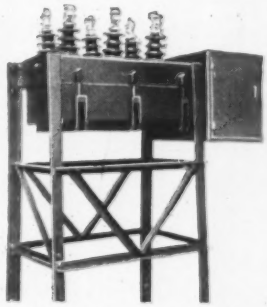
Purpose of Berry Ductility Tension Machine is to test asphalts of varying thicknesses: registering the conventional ductility of the asphalt specimen by



showing length it travels before breaking, and recording this upon a chart simultaneously with recording of specimen's tensile strength. This new method has advantage that there is recorded at all points on the chart the actual relation between ductility and tension, thereby providing essential data on physical characteristics of asphalt. The machine was developed by combined efforts of Humbolt Mfg. Co., Chicago, Ill., and *Berry Asphalt Co., 1472 W. 76th St., Chicago, Ill.*

## Oil Circuit Breakers

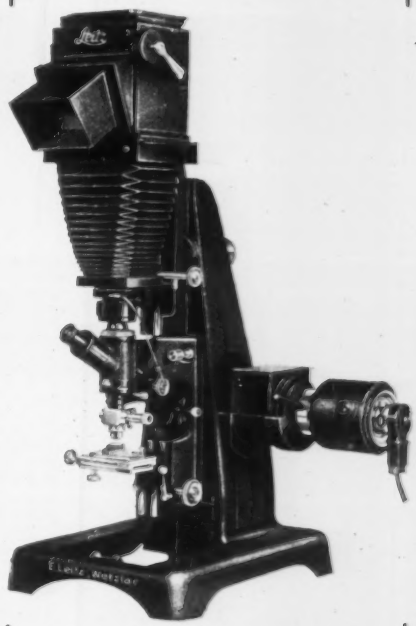
A new line of 15,000-volt oil circuit breakers, utilizing the oil-blast principle and incorporating a simpler operating mechanism, simpler internal mechanism, and fewer bearing points, comprises



Types "FLO-1A," "FLO-1B" and "FLO-1C," with interrupting ratings of 50,000-, 100,000-, and 175,000-kva, respectively. New device has a horizontal break with the three poles in a single rectangular steel tank. Oil blast ports provide extremely rapid extinction of the arc with minimized burning of the heavy arcing contacts. A horizontal oil baffle divides the tank into two parts interconnected by three ports, one opposite each pair of contacts. Main contacts are of the heavy wedge and finger type, with silver-to-silver contact surfaces. Stationary fingers are pivoted to be self-aligning with the wedge-shaped copper blades securely attached to the horizontal contact carrier. Operating mechanism on all breakers of this type classification is built as an integral part of the breaker whether manually- or solenoid-operated. Bushings are one-piece wet-process porcelain. "Type D-304" bushing current transformers are available, for providing direct instantaneous trip from 85 primary amps. up and time trip, with relays, from 90 amps. up. Approximate dimensions of a frame-mounted breaker are: 8' high, 2'3" wide, 5' deep.—*General Electric Co., Schenectady, N. Y.*


Leitz

PANPHOT



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Can be used also for micro-projection, drawing and photo-micrography in transmitted or reflected light.

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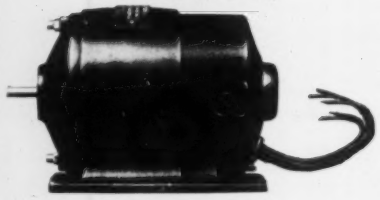

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## Astatic Dynamometer Type Portable A-c-d-c. Instruments

Designated as "Model 19," a new line of astatic electrodynamometer type a-c-d-c. instruments including milliammeters, ammeters, voltmeters and wattless-component indicators, has been brought out in two degrees of accuracy: "Series 1" 0.2% and "Series 2" 0.5%. The line includes single-, double- and triple-range instruments and even one quadruple-range voltmeter, also choice of external multipliers or special deep-case instruments for continuous duty on voltages

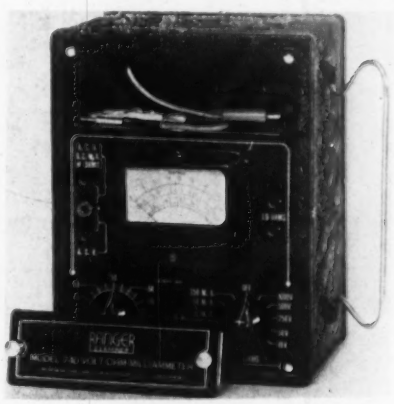
above 300 volts. Scale length is 5½"; pointer-reflecting mirrors are standard, and elimination of all metal other than wires eliminates frequency, wave-form and power-factor errors at all commercial frequencies. Astatic properties are obtained by electrical design: two moving and two field elements having reversed-winding connections, also by mechanical construction: no space between the two moving coils, so that effects of external field are equal and opposite. Temperature influence is minimized also by electrical means (low-ratio resistance in voltmeters, balanced coefficients in ammeters) and by mechanical means (spring material with compensating coefficient) so that temperature error is negligible. Size, 4"×6¼"×7⅛"; weight, 4½ lbs., except "specials" mentioned above. *The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.*

## Out-of-Step Relay for Synchronous Machines

A new relay to prevent continued operation of synchronous machines out of synchronism with their connected system (or to separate large interconnected systems at a specific location in the event of an out-of-step or unstable condition between the sources of power on both sides of this location) consists of an instantaneous overcurrent unit, a single-phase power-directional unit, an auxiliary unit to increase the operating speed, a notching device, and a time-delay element for resetting the notching device. All these are mounted in a standard 5½"x16" universal case. A capacitor and resistor for the notching unit are mounted externally. New device operates on an overcurrent and power-directional principle: When two synchronous machines, or groups of machines, pull away from each other in phase angle, the current and power interchange increase. When this action proceeds far enough, i.e., approx. 90° between internal voltages, the over-current unit picks up its contacts to energize the armature coil circuit of the polarized auxiliary unit. As the phase angle continues to increase, the current likewise increases but the power interchange decreases, and at about 180° between internal voltages the power reverses. This causes the power directional unit to function and through the closed contacts of the auxiliary unit causes the notching device to step up one notch. At 540° the second notch is stepped up and at 900° the third, closing main contacts in the circuit breaker tripping circuit to disconnect the machine. A target gives visual indication after operation; the contacts are automatically reset after a time-delay, but the target must be reset manually. The notching unit, in each of its notch-steps, closes contacts in the coil circuit of the timing unit. This coil circuit also includes the normally-closed contacts of the overcurrent unit so that when the first notch is made and the overcurrent unit drops out as the angle approaches 360°, the timing unit begins to operate. If the overcurrent unit fails to receive another impulse within the time setting of the time-delay unit, the contacts will be reset. This same action can take place after the second notch if the protected machine slips two pairs of poles and then stabilizes. It will always occur after the closing of the contacts on the third notch has tripped the circuit breaker.—*General Electric Co., Schenectady, N. Y.*

## Volt-ohm-milliammeter

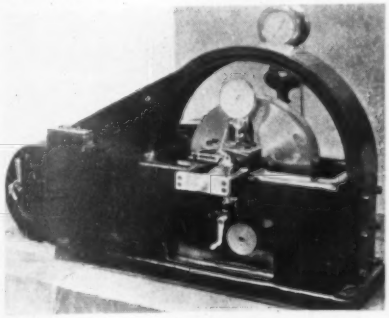
Wide-range testing capabilities and handy portability characterizes "Model 740" Volt-ohm-milliammeter, a single-tester addition to the "Ranger Examiner" line of testing instruments (see *Instruments*, May 1936, page 125, June 1936, page 153). The new unit has a Triplett precision instrument with scale



readings: 10-50-250-500-1000 volts a-c. and d-c., at 1000 ohms per volt; (d-c. accuracy 2%; a-c. 5%); 1-10-50-250 d-c. milliamperes; 0-300 low ohms, high ohms to 250,000 at 1½ volts; provision for higher resistance readings by addition of external batteries. Metal case with black electro-enamel finish measures 5⅞" × 7⅞" × 4⅛". Built-in compartment with snap-on cover holds all accessories. Panel is silver and black. Carrying handle folds against side of case when not in use.—*The Readrite Meter Works, 3212 Harmon Drive, Bluffton, Ohio.*

## Machine for New High-velocity Method of Impact Testing

Unexpected failures of materials when subjected to impact speeds of more than 30 ft./sec. led to a series of investigations at the Watertown Arsenal which brought out a previously unrecognized correlation between static and dynamic tests, pointing to importance of considering velocity factor if true dynamic properties of materials are to be determined, and leading to development (by H. C. Mann and Capt. R. K. Haskell) of a testing machine capable of (1) producing velocities up to 500 ft./sec., (2) indicating the exact speed and (3) indicating the energy absorbed to break the specimen. Machine consists of two separate parts: pendulum as means of measuring energy, and rotating wheel and related parts which serve to develop necessary Kinetic energy and controllable velocity. These two systems have no interconnection except through specimen during process of rupture. A 15 h-p. motor brings wheel up to speed and, at desired velocity (indicated by tachometer), external mechanism is tripped, causing specimen to be struck and ruptured. Pendulum is normally at rest, moves only as result of impulse imparted to it through test specimen. Data service: Purchasers are asked to forward such results as they are willing to disclose on SAE steels periodically to Arsenal, where H. C. Mann will edit digests which will be distributed quarterly by Riehle Div. to cooperating users.—*Riehle Div., American Machine & Metals, Inc., 100 Sixth Ave., N. Y. City.*

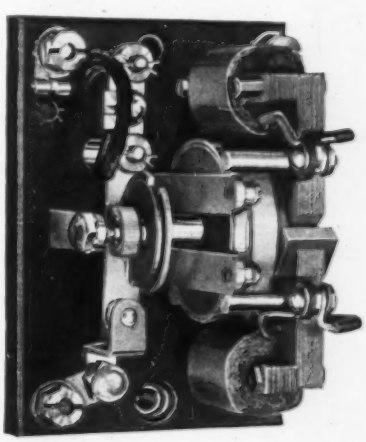


## Manual Voltage Regulator

An improved voltage regulator for a-c. circuits, known as "Type TH Transtat," is available in various standard sizes for controlling voltage to loads up to 2.5 kva. on either 115- or 230-volt lines. It permits control of voltage from practically zero to normal line potential with maximum rated current obtainable at any setting, also stepping up output to values considerably higher than line voltage. The control throughout the entire range is by uniform increments of the order of 0.5 volt each. Equipment is said to have no effect upon power factor, nor to cause wave-form distortion, line surges, or interference to radio receivers. It consists of a transformer coil surrounding an annular steel core and a carbon brush arranged so that it may be rotated in continuous contact with a commutator formed on the winding by removing insulation from the wire in a narrow track around the circumference. In this design voltage is varied by rotating the brush which makes contact between the transformer winding and the load. As direct contact can be made with each turn of the winding, "continuous" control of voltage is possible.—*American Transformer Co., 178 Emmet St., Newark, N. J.*

## Motor-operated Timing Devices

Several motor operated timing devices have recently been added to makers' line of timing devices which also includes thermal, inertia, air dashpot and capacitor types. One of these is of the immediate recycling type: the synchronous motor of the timing device drives cams through a chain of gears. At the time the starting impulse is received, the motor starts and a solenoid is energized to operate a clutch which connects the cams to the motor. At the end of the cycle, the motor is deënergized by means of a contact on one of the cams, and the clutch holds the cams in position. When the solenoid is deënergized, the cams are returned to the starting position by means of a spring. The timing is adjustable over a wide range and practically any desired arrangement of load contacts may be furnished. Another new timing device (illustrated) is of the continuously rotating type: by means of gears, the cams are made to revolve at 1 r.p.m. or any other desired speed. The contacts may be arranged to be closed for any duration up to half the time required for one revolution if the timing is adjustable or up to the full time required for one revolution if the timing is not adjustable. Almost any desired number of adjustable or non-adjustable contacts may be furnished. —*Struthers Dunn Inc., 125 No. Juniper St., Philadelphia, Pa.*

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# Hardness and Hardness Measurements

By S. R. WILLIAMS

Professor of Physics, Amherst College

## PREFACE

TOWARD the close of the World War, the Engineering Division of the National Research Council formed a special committee for the purpose of making a critical study of the apparatus, the methods of procedure and the results obtained by the different instruments employed in measuring mechanical hardness. Among other duties the committee was asked to report on the possibility of formulating a general definition of hardness. It was as a member of this special committee that the author, a physicist, became interested in what then seemed to be largely a metallurgical problem.

Fundamentally, hardness, so-called, rests on various physical properties and its measurement is a problem for the physicist as well as for the engineer. No physicist need apologize for displaying a curiosity about "Hardness and Hardness Measurements," though it seems fair to say that metallurgical engineers up to the present time have studied the problems connected with hardness more assiduously, and have devoted to these problems more space in their writings, than have other groups.

For more than twenty-five years the author has been engaged in a study of magnetostrictive effects. These are the magneto-mechanical[3] effects whereby changes in dimensions and in forms are produced by subjecting materials, particularly ferromagnetic bodies, to the influence of magnetic fields. Magnetostrictive effects are intimately associated with the physical property of hardness. When in 1923 it was found[1] that mechanical hardness could be altered by magnetic working, the study of the relations between magnetism and hardness entered upon a most alluring phase. This interest has been greatly enhanced by the valuable and constructive work of E. G. Herbert[2] of England, who has confirmed and extended the idea of magnetic working of metals.

The National Research Council's committee on hardness laid out at its first meeting a comprehensive program of study, the importance of which could hardly be overestimated. It is unfortunate that the work so well begun had to be discontinued when the committee was finally disbanded for lack of funds.

If reasons for writing this serial are necessary, they are

(*a*) that an active study of the subject of hardness and hardness measurements may be revived;

(*b*) that a more general outlook on the problem may be promoted. A theory of hardness, to be comprehensive, must apply to all solids. There is danger that the metallurgist may limit himself to metals, or the mineralogist to his minerals;

(*c*) that by bringing together our present literature it may 1, focus attention on the need of further study of this very important subject; 2, clarify present day conceptions of hardness as a physical property of solid matter; 3, suggest a comprehensive definition and, 4, lead to a more unified method of measurement. Such a goal is worthy of further consideration, even though not attainable.

If the author of this serial should raise many questions in the minds of his readers, which he himself cannot answer, but which induce the readers to begin simple and basic researches on the problems of hardness and hardness measurements, these pages will have served a useful purpose. This small treatise on hardness and hardness measurements is a pioneer attempt on the part of a physicist to clarify concepts of hardness and to improve the methods for measuring hardness, *if such a property exists.*

## INTRODUCTORY

ONE sometimes arises in the morning and says, "How comfortable that bed was! It was so soft!" Or it may be the opposite, "Gee, wasn't that a hard bed!" By what "measuring rod" was comfort determined? Evidently the more easily one's bones sank into the mattress the softer the bed felt. Penetration, then, is the factor whereby the hardness of a bed is judged.

"As soft as a baby's skin" is a common simile. In this case the basis of judgment is not so much penetrability as surface smoothness. The resistance to sliding or the friction between the surfaces of one's hand and of a baby's skin has entered as a factor in making the decision between hardness and softness. The cleaning powder which "hasn't scratched yet" is a softer one than the one which does scratch porcelain and enamel ware. The ability of one material to scratch another, then, is one more criterion whereby the relative hardnesses of two bodies may be judged. The more abrasive one body is than another, the harder it is. Nevertheless, saying that a surface is "smooth as glass" is not saying that the surface is soft, for glass is not a soft body. In fact, "glass hard" is a term used to designate a high degree of hardness. In the case of one body scratching another, some point of the harder body has penetrated the softer body and in such a way as to tear off some of the particles of the latter or permanently to displace them to one side or the other. Thus, with certain modifications, the ability of one body to penetrate another seems to be a criterion whereby relative hardness or softness is determined in our every-day experiences. Resistance to penetration may, therefore, serve as a preliminary definition in approaching the subject of "Hardness and Hardness Measurements." This definition has at least an historical and subjective basis to make it worthy of consideration. As the story of hardness and hardness measurements unfolds, it will be observed that this definition is by no means comprehensive. It is not a definition of "absolute hardness," if by that expression we mean hardness whose definition is arbitrarily agreed to by an authoritative body and universally employed in all measurements of hardness. Nevertheless, people in general understand what is meant by the term hardness. The term as used in common parlance fits in with the more specific

[1] S. R. Williams, A Correlation Between the Mechanical Hardness and the Magnetostrictive Effects of Ferromagnetic Substances, *Transactions American Society Steel Treating*, Vol. 5, 1924, pages 362-368.

[2] E. G. Herbert, Hardening Metals by Rotating Magnetic Fields, *Proceedings Royal Society of London* (Series A), Vol. 130, 1931, pages 514-516.

concept of mechanical hardness as understood by the physicist and the engineer. This is by no means saying that anyone understands what hardness is or that it rests on some specific property of matter. In a recent paper[1] the author pointed out seriatim that the method of measuring hardness by an indentation method rested upon four specific factors at least. Other methods will introduce other factors. Hardness cannot be reduced to one or even a few simple factors. Hardness, like the magnetic properties of iron, is exceedingly complicated but that should not deter one from studying and discussing those properties. A defeatist's program does not carry one very far.

Some of the modern text books of general physics[2] devote at least a short paragraph to the discussion of hardness, and books on metallography[3] at least one chapter. This indicates in some measure the relative importance which physicists and metallographists, respectively, attach to this property of the material universe. The mineralogist[4] also employs hardness measurements in the classification of minerals and devotes not a little space to the methods used in its measurement. Early observers in the field of hardness measurements, Mohs, Réaumur and Haüy, were mineralogists. Both the metallurgist and the mineralogist are interested in hardness measurements, simply because they serve as tools for the classification of materials and the standardization of products. They are not fundamentally concerned with the property of hardness *per se*, except insofar as better understanding may contribute better methods for its measurement. This throws the burden of a better understanding of hardness back on the physicist where it rightly belongs, for the physicist is certainly concerned with the physical properties of matter, which underlie the thing we call hardness.

Judging by the space given to the study of hardness of materials, the physicist has not recognized it as one of the essential properties of matter; the engineer has believed it to be of fundamental importance. The physicist has talked about hardness, but has done nothing about it. This is a deplorable situation in view of the fact that modern physics has many useful tools and theories to throw light on the question as to whether there is such a thing as "absolute hardness."

There are all sorts of conceptions as to what constitutes hardness if one may judge by the methods employed to measure it. There is hardness as measured by penetration, by scratching, by resilience, by machinability, by yield point, by electrical and magnetic properties and by many other related physical properties. Even if the definition of "absolute hardness" cannot be realized, it will be of some value to make clear, for instance, what sort of hardness is needed in a good cutting tool for use on a lathe, a milling machine or a shaper. The machinist knows he has a good cutter. Can the physicist or the engineer tell him exactly why? Such a possibility would be a real step forward in our understanding of what hardness means. The importance of understanding the significance of hardness tests cannot be overestimated. It is a conservative statement to make, that no other tests on materials approach in numbers the tests made under the name of "hardness tests" as the criteria whereby materials may be classified or selected for special purposes.

In an excellent article by Tuckerman[5], an Engineer-physicist of the National Bureau of Standards, the importance of discrimination between these relative values of hard and soft materials is brought out in this statement: "Nobody doubts that the hardness of the diamond is one of its most important physical properties, nor that it is necessary to accurately control the hardness of metal cutting tools or of balance knife edges, nor that the difference between 'hard' and 'soft' glass is of very great technical importance, nor that there is a great difference between 'hard' and 'soft' woods, or between 'hard' candy and chocolate creams, a difference which is of considerable commercial importance."

There are two fields in which hardness measurements are particularly important:

1. *Determination of the suitability of a material for a certain purpose.* It is important to know whether the hardness of the ball races and of the balls themselves in ball bearings is sufficient to make them fit for bearing purposes. Lead balls and races would not last long because they are too soft; hardened steel serves much better for bearing materials. Here an absolute hardness is not essential, if once a bearing material has been found whose hardness has shown it to have a proper bearing quality. Of course, the acid test of materials is their behavior in actual use. Once such a specimen is found, its hardness may be used as a standard and all other pieces to be used for the same purpose may be accepted or rejected on the basis of comparative tests. The author has reports from several manufacturing plants in which this procedure is followed. It seems to be the best procedure available at the present time. Comparative tests, then, satisfy every purpose in testing for suitability. Many of the tests mentioned three paragraphs above would fulfill the conditions for making these relative measurements. Hardness tests are used at every step of the way in determining whether the various materials which go into an automobile are suitable for the component parts of the completed machine.

2. *Maintenance of uniformity of product* constitutes the second great use of hardness measurements. In a sense this is but one phase of the first important use to which hardness tests are applied.

In reply to an inquiry, the late Dr. George K. Burgess, Director of the National Bureau of Standards, wrote,[6] "We have been working on the relation between the Rockwell and the Brinell numbers and have developed conversion formulas which give reasonably accurate results. The average error in converting from one to the other is about 5 percent and the maximum error is about 10 percent. Perhaps the most satisfactory way to look at the matter is that none of these methods measures the true hardness of the material. Of course everything depends on the definition you accept for hardness. Each of these methods, however, does have practical use in the metal industries and the fact that one cannot be converted into the other, simply shows that the hardness as measured by one of them is not the same as the hardness measured by another. We have, therefore, avoided using the term 'hardness' in referring to the results obtained by the tests we have made. We speak of the 'Brinell number' or the 'Rockwell num-

[1] S. R. Williams, The Measurement of Hardness, *Instruments*, Vol. 9, 1936, pages 221-223.

[2] A. W. Duff, Physics, 7th Ed. Blakiston, Philadelphia, 1932, page 115.

[3] Z. Jeffries and R. S. Archer, The Science of Metals, 1st Ed., 1924, pages 19-21, 403-448.

[4] B. Talmage, Quantitative Standards for Hardness of the Ore Minerals, *Economic Geology*, Vol. 20, 1925, pages 531-553.

[5] L. B. Tuckerman, Hardness and Hardness Testing, *Mechanical Engineering*, Vol. 47, 1925, pages 53-55.

[6] May 15, 1926.

ber' and not of the 'Brinell hardness number' and 'Rockwell hardness number'." Tuckerman" points out that there are no reliable conversion tables connecting 500 Kg Brinell hardness with 3000 Kg Brinell hardness, to say nothing about the difficulties of attempting to relate Mohs' hardness scale with Brinell hardness.

It therefore follows that to correlate various methods of measuring hardness is not so important as to standardize some particular method that will lead to definite specifications in the production and inspection of finished articles. The crying need is that out of the many ideas now involved in the term "hardness" there should eventually emerge an absolute method which will enable hardness to be included among the specifications of the physical properties called for in the finished product.

In a physics laboratory one may use a first class galvanometer and make comparative measurements. It may serve in a useful capacity its rôle as a comparator. However, such an instrument can be calibrated in terms of absolute units. When so employed it has a wider range of usefulness and the observer can talk more intelligently about his results when using absolute units than when employing relative measures. Lord Kelvin once said, "When you can measure what you are speaking about, and can express it in numbers, you know something about it; and when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of a science."

This seems to the writer a goal toward which we should strive in the measurement of hardness, the ability to express hardness in terms of an absolute scale rather than in relative terms. The history of the establishment of units in any field of measurement has been that of a group meeting together and agreeing that such and such a physical embodiment shall serve as the standard unit. The agreement that a certain platinum-iridium bar should serve as the international standard of length is a good illustration of this point. Such an agreement can never be secured until there is a clear, definite understanding of the thing or property which is to be measured.

One other question might be raised at this point: Would it clarify our thinking if we eliminated the word "hardness" from our scientific vocabulary? The author's point of view is that the term is so firmly entrenched in our everyday vocabulary, that we wouldn't go far before we began to use it again. For instance, one could talk about measurements of penetration, or measurements of machinability, scratchability and other terms already used. Whatever we call it, back of each measurement is a something which we might just as well call hardness from the start and keep on calling it that, until we know something about it.

> SOCRATES: But why should we dispute about names when we have realities of such importance to consider?
>
> GLAUCON: Why, indeed, when any name will do which expresses the thought of the mind with clearness?
>
> —Plato: "The Republic."

Friction is the resistance to motion which one surface offers to another as the two surfaces slide past each other. Friction is a function of the physical condition of the surfaces which in the end does not rest on any one physical property. As an illustration, there is a great deal of friction between two pieces of sandpaper when they are rubbed together. The friction will, in general, depend upon the size of the grains of sand which have been used. Not only does the size of the grain play an important rôle but also the condition of the grains—whether they have rounded-off corners or are jagged. In the case of a steel shaft rotating in a phosphor-bronze or in a Babbitt metal bearing surface, the ease with which the shaft turns depends upon the original polish given to the two bearing surfaces in contact and upon the molecular structure of the materials. No matter what the final polish, there will be some friction due to the molecules of one surface dropping into the interstices between the molecules of the other surface. As the bearing is used the steel shaft itself becomes smoother because of the process of cold working which goes on in the surface of the steel shaft. It is hardened by this process and smoothed out and thus makes the friction less than at the start. In spite of these various factors which affect the resistance to motion arising from friction, we have worked out a fairly satisfactory measure of friction which we express as a coefficient of friction. Can one work out a coefficient of hardness? Perhaps in the end it will be a coefficient of penetrability, but whatever it is, it will rest upon several physical properties and not upon one.

There are several mechanical devices which the manufacturers call "hardness testers." They are wonderful machines for testing the suitability of materials for definite purposes. In our present state of knowledge we do not know all the factors which control the tests for suitability, whether we call them hardness tests or tests for penetrability. Wouldn't it be worth while in using a "hardness tester" to know more about the physical properties which enter into a test for hardness and make the machine with which the test is made so valuable an adjunct in any manufacturing establishment? The author believes such a study an important one.


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# Training Your Own Instrument Men

By ALFRED G. MOON

IN the preceding article* the writer dealt chiefly with organization but undertook also to outline industry's need for trained instrument men, and indicated the difficulty of obtaining such men in the open market. The present article describes in detail a three-year apprenticeship course which has proved successful. This course was designed primarily to train men to service instruments in an oil refinery but the same general plan would apply also to any large plant in any of the processing industries. It can easily be modified: its divisions of allotted time can be made to fit the industry, the particular plant, and the types of instruments in use.

### BASIC CONSIDERATIONS

Before deciding on the details of any training course, three important basic factors must be considered:

(1) Do the needs of the plant require that the instrument mechanics be specialists—each familiar with one make—or all-around men who can service any of the makes used in the plant? The first type can be more easily secured but more of them would be needed in a large plant where different makes are used. At present, most control boards installed in plants have five or six makes represented, and this variety will probably continue to be the rule for some years to come. Not much imagination is needed to visualize the confusion that would result if five or six men had to be called on whenever one control board had to be serviced. We therefore favor the all-around type of mechanic who, when trouble develops in any instrument on the board, can fix it—be it mechanical or electrical; indicating, recording or controlling; flow, temperature, pressure or liquid level.

(2) The physical layout of the plant, the instrument scattering or concentration, and the division of types and makes represented, must all be considered in determining the major division of the training course total time into sub-courses and periods. The types and makes of instruments represented must be tabulated numerically, and the time divisions assigned not only on the basis of numerical proportion but also with due consideration of the subject-matter to be learned by the mechanics.

(3) The course must be broad enough to include *all* the instruments used at the plant, from the simplest to the most complicated types. If the men do not have a broad base on which they can build their future experience and practice, we shall end up with mechanics who will not be able to solve problems as they arise, and in some instances will not be able to determine whether an instrument is performing as it should.

### QUALIFICATIONS OF CANDIDATES

In selecting candidates for training we felt that:—

(a) The apprentices should be young men who would be willing to stick through the entire training period, and not become impatient as older men might.

(b) Single men should be preferred, because men having home responsibilities might not be mentally free to absorb the instruction, nor be in position to support a family on apprentices' wages.

(c) A high-school education which included trigonometry, algebra, plane and solid geometry and physics was the minimum educational requirement. This would enable the candidate to follow and understand the preliminary instruction until his studies at night school had carried him further along. We realized that technically-trained men would make the best candidates, but decided against enrolling them, as we wanted instrument mechanics who would be more apt to be content to make their life's work in this field. A technical graduate with the proper amount of ambition would eventually look for wider fields. Accepting mechanics from other lines was regarded as risky because, if they had the proper educational background and had learned a trade, they were likely to have family responsibilities and not be content with an apprentice's pay.

(d) Good health, straightforward appearance, alert mentality were requirements for admission. The wiry, nimble type were preferred to the heavy, slow-moving men, as being apt to handle small and delicate parts more readily. (It may be noted, however, that one is easily fooled in this regard. The writer has in mind two mechanics whose physical appearance leads one to think of heavy muscular work, but these men have a most delicate touch, and are expert at micro-manipulation of parts under a powerful glass.)

(e) We looked also for signs of ambition, self-assurance and "aggressiveness." These qualities we judged with the thought in mind that the instrument mechanic must work with and satisfy the operator, who might be wrong in his idea, severe in his criticism and yet must not be offended by a know-it-all attitude on the part of the service man.

### DIVISIONS OF TIME

The total length of time necessary to impart the required basic information and training was arrived at by considering what had to be covered to establish the type of mechanic needed by our plant. A three-year course was fixed as the minimum requirement and the men would be rated as third-class mechanics. The difference between a third-class man and the higher grades, we feel, is a matter of experience and successful demonstration of ability to coöperate with all types of operators after the apprentices are on their own. It is our thought that it will generally take at least two years after finishing their course before the men can be rated as first-class mechanics.

The time schedule was set up to cover the work in the plant on a basis of 6,000 hours; in addition we required night school work. Incidentally, the cost of these night courses is borne by the men themselves,—the company does not share in it. The men are eager to have the training given by the company and therefore meet this requirement willingly.

The division of time in plant work was made as follows:

| | *hours* |
|---|---|
| 1. Mechanical Laboratory Shop—Mechanical Sec. | 750 |
| 2. Mechanical Laboratory Shop—Electrical Sec. | 1000 |
| 3. Plant Section "A" | 1920 |
| 4. Plant Section "B" | 900 |
| 5. Plant Section "C" | 1100 |
| 6. Lectures | 200 |
| 7. Visits to instrument manufacturers | 130 |
| Total | 6000 |

*A. G. Moon, Organizing the Plant Instrument Services. *Instruments*, Vol. 9, Dec. 1936, pages 331-334.

The division of the time allotted to each section was made on the basis of the relative importance of instruments in each section and the predominance of various types. These divisions were made as follows:

| *1. Shop—Mechanical Section* | *hours* |
|---|---|
| Indicating gage repair & calibration | 150 |
| Thermometer checking & standardization | 100 |
| Recording instrument repair | 100 |
| Displacement meter repair | 75 |
| Thermocouple fabrication | 100 |
| Control valve repair | 100 |
| General shop work | 125 |
| Total | 750 |

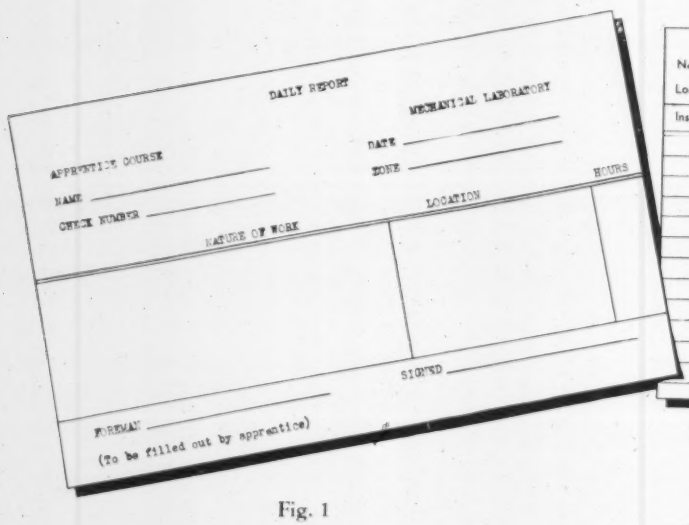



Fig. 1

| *2. Shop—Electrical Section* | *hours* |
|---|---|
| Indicating, recording, controlling, potentiometer repair, changing & standardization | 400 |
| Marine instruments—gyros, etc. | 150 |
| Switchboard & test instrument repair | 200 |
| Thermocouple wire standardization | 75 |
| Special instrument fabrication | 100 |
| Planimeters* | 75 |
| Total | 1000 |

*Not strictly electrical, but checking and adjustment of planimeters used by the Accounting Department has always been done by the men on the electrical bench.

| *3. Plant Section "A"* | *hours* |
|---|---|
| Instruments at Still No. 1 | 400 |
| Instruments at Gas Plant | 400 |
| Instruments at Still No. 2 | 300 |
| Instruments at Still No. 3 | 400 |
| Instruments at Boiler House No. 1 | 200 |
| Instruments at Yard, General | 220 |
| Total | 1920 |

| *4. Plant Section "B"* | *hours* |
|---|---|
| Instruments at Still No. 4 | 300 |
| Instruments at Still No. 5 | 100 |
| Instruments at Gas Plant | 100 |
| Instruments at Boiler House No. 2 | 150 |
| Instruments at Yard, General | 250 |
| Total | 900 |

| *5. Plant Section "C"* | *hours* |
|---|---|
| Instruments in Plant Group No. 1 | 125 |
| Instruments in Plant Group No. 2 | 175 |
| Instruments in Plant Group No. 3 | 175 |
| Instruments in Plant Group No. 4 | 75 |
| Instruments at Still No. 6 | 100 |
| Instruments at Boiler House No. 3 | 200 |
| Instruments at Yard, General | 250 |
| Total | 1100 |

*6. Lectures*

The foregoing field work is supplemented by a series of lectures and demonstrations covering the period of the course. These lectures are one hour each, given on company time. Home study and class tests are part of the routine, dependent on the decision of the individual giving any particular series.

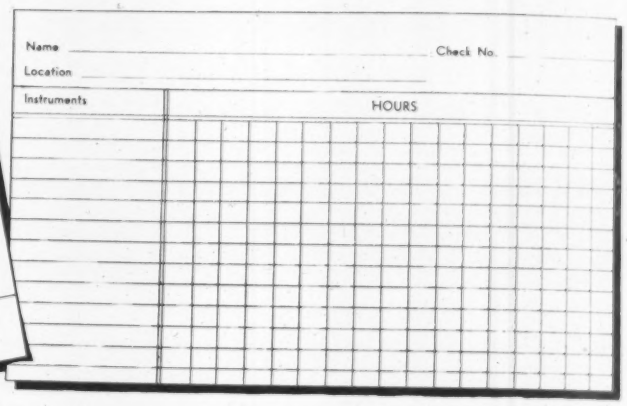



Fig. 2

The lecture periods are divided as follows, each group of lectures being given by a specialist, selected from the plant supervisory force and some guest speakers:

| | *hours* |
|---|---|
| Application and measurement of pressure | 5 |
| Theory and measurement of temperature | 10 |
| Theory of fluid flow | 20 |
| Theory of orifice design | 20 |
| Mechanical instruments | 40 |
| Theory of combustion | 20 |
| Boiler instruments | 20 |
| Electrical instruments | 45 |
| Operations and processes | 20 |
| Total | 200 |

*7. Visits to Instrument Manufacturers*

Just before the completion of the specified course it is desirable to have the apprentices spend some time at the plants of the suppliers of the more numerous types used. There they will have a chance to coördinate what they have learned of each make, and be instructed in some measure by experts whom they probably could not otherwise meet. The time is divided as follows:

| | *hours* |
|---|---|
| Manufacturer "A" | 40 |
| Manufacturer "B" | 30 |
| Manufacturer "C" | 30 |
| Manufacturer "D" | 20 |
| Manufacturer "E" | 10 |
| Total | 130 |

### SUPPLEMENTARY EDUCATIONAL WORK

As noted above, the men accepted were required to attend night school, and the time divided as follows:

*First Year:* At a trade school, taking chipping, filing and simple bench work, in order to become familiar with the feel of tools and working to dimensions.

*Second Year:* At a technical night school, taking as a minimum, elements of engineering mathematics and mechanical drawing. Those contemplating working for a certificate in Mechanical or Electrical Engineering could take what the school required.

*Third Year:* Minimum requirement, elementary electricity and hydraulics, or continuation, with studies prescribed by school for engineering certificate. (It is gratifying to note that half of the men elected to study for a certificate, which requires six years' night school work.)

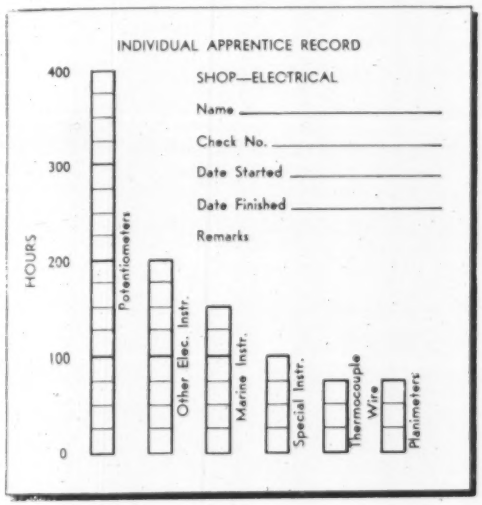



Fig. 3

### SUPERVISION OF TRAINING

Having set the time divisions and laid out the course of study and work, the next decision involved how it was to be applied. We have always believed that doing work taught faster and with more lasting results than merely demonstrating. We could not carry a group of eight men around from one operation to another without defeating the aim of the course. Consequently, we started with one in Shop-Mechanical, one in Shop-Electrical, and two in each of the three plant sections.

The problem of keeping track of these men now arose. To accomplish our aims we must watch that each man spends the scheduled time properly, is moved when his time is up, receives time on the various instruments in each minor group, is guided properly along the path of experience, and is not taxed beyond his ability to perform in the beginning nor allowed to act as a helper when he should be on his own as he progresses. In order that the detail involved in all this could be properly covered, one man was made responsible for following the progress, ordering moves when due and reporting any tendency to keep a man too long on some particular phase of the training. This latter tendency is only natural on the part of a field foreman when he finds a man getting good at one thing.

In keeping track of the apprentices' work and progress the Daily Report shown in Fig. 1 is filled out by each apprentice and sent to the office.

These daily records are entered on a card for each man, shown in Fig. 2.

Once a week the accumulated hours are transferred to a block diagram for each section. This enables the Supervisor and General Foreman to see at a glance how the man's time is progressing in each minor group. These diagrams form the basis for periodic notice to the field foremen as to where the men shall be placed. A specimen diagram is shown in Fig. 3.

A summary diagram is maintained and, as the block representing the total hours for each major division is reached, the man is moved to the next stopping place. This diagram is illustrated in Fig. 4.

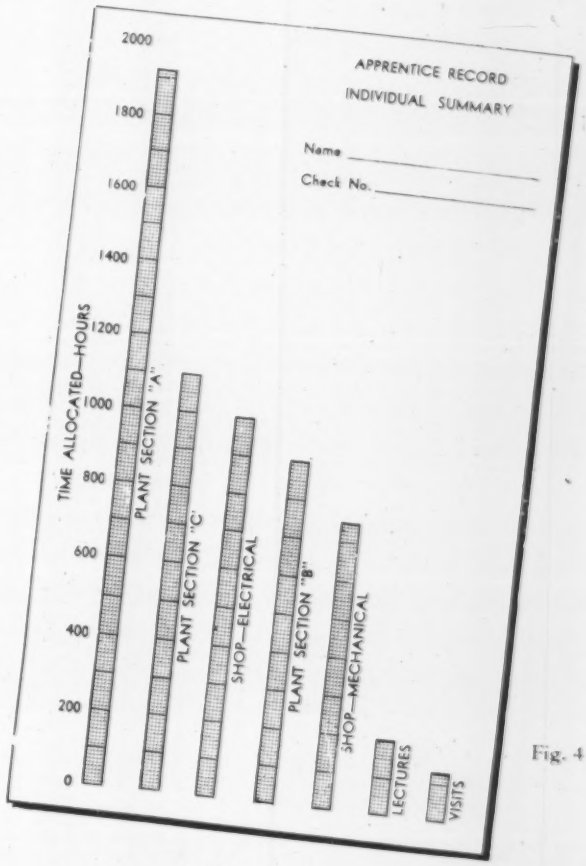



Fig. 4

At the outset of the course the apprentices in the field were not provided with tools, nor were they permitted to do more than help the various mechanics to whom they were assigned. At the end of six months they were given a few of the larger tools, such as those used on pipe work, and allowed to work under a mechanic's direction. At the end of the first year they were given the tools necessary to do the simpler jobs on instruments. At the end of the second year they were given a complete kit and assigned to regular routine; only when moved into a new section did they have a regular mechanic with them, until they acquired the necessary familiarity with locations and operations.

### PROGRESS REPORTS

We regard the rating of the progress of the embryo mechanics as an important function of proper supervision, and have tried to make it as fair as possible. We rate the men every six months, and report the results to the man himself and to the plant Personnel Division.

This function is obligatory, in a sense, because each man was told that he would have to maintain a satisfactory standard or be dropped. We started with eight men, dropped two for not holding up at the end of eighteen months (third rating period), and warned one. At the end of the fourth rating period this man had shown great improvement and was retained.

Name John Doe

Number 999

| ITEMS | RATINGS | | | | | | RESULT AS REPORTED |
|---|---|---|---|---|---|---|---|
| | "1" | "2" | "3" | "4" | "5" | "6" | |
| Interest in Work | A- | B | A | C | B | | B |
| Application | B | C | B | D | B | | C |
| Ability to Learn | B | B | C | B | C | | C+ |
| Self-reliance | B+ | C | B- | C | A- | | B |
| Accuracy | C | B | A | B | B- | | B |
| Speed | B- | C | B | B+ | C | | C+ |
| Reliability | A | B | B- | C+ | B | | B |
| Initiative | B+ | C | B | B | B- | | B |
| Judgment | B | C | B- | B | A- | | B |
| Conduct | B | B | B+ | B | C+ | | B |
| | | | | | Average | | 77½ |

Fig. 5

In rating the men, the Course Supervisor goes to each foreman who has handled the men and also gets the opinion of the regular mechanics who have worked intimately with the men. The opinions are collected singly and averaged so as to avoid personal bias as far as possible. The ratings are based on ten items, and to remain, a man must be "average" or better, when the individual items are evaluated. Fig. 5 shows the general appearance of a rating report, when the field men have been consulted.

The above valuations are expressions of opinion founded on observation, as guided by the check-list shown in Fig. 6 (for which we do not claim originality: something like it is generally used in personnel work).

All of this rating must be tempered with thought of the type of work being done by the man, as well as the characteristics of the man himself. Some men get along or "click" better with certain foremen than other men of equal or greater ability, and this fact must be taken into account. Final judgment must also evaluate the type of instrument man likely to result from the training of the individual; will he be best as trouble-shooter, will routine be his *forte*, or should he be placed at detail repair such as on the electrical bench?

RATING GUIDE TO BE USED FOR SEMI-ANNUAL CHECK-UP

| *Characteristics* | A *Exceptionally Good* | B *Above Average* | C *Average* | D *Below Average* | E *Exceptionally Poor* |
|---|---|---|---|---|---|
| Interest in Work | Enthusiastic | Quite Interested | Average Interest | Lacks Interest | Disinterested |
| Application | Exceptionally Industrious | Good Worker | Steady | Erratic | Lazy |
| Ability to Learn | Exceptionally Quick to Learn | Apt | Learns Readily | Slow to Learn | Dense |
| Self-reliance | Excellent | Self-reliant | Confident | Lacks Confidence | Timid |
| Accuracy | Exceptionally Accurate | Accurate | Average | Inaccurate | Careless |
| Speed | Exceptionally Rapid | Rapid | Average | Slow | Very Slow |
| Reliability | Trustworthy | Reliable | Satisfactory | Irregular | Unreliable |
| Initiative | Excellent | Good | Fair | Poor | Lacks Initiative |
| Judgment | Exceptionally Good | Good Common Sense | Ordinary | Lacks Judgment | Rash |
| Conduct | Exceptional | Gentlemanly | Well-Behaved | Too Talkative Troublesome | Very Poor "Fresh" |

Fig. 6

## CONCLUSIONS

Pressure of economic necessity is the force behind the establishment of such courses as described above. With the continued expansion in the use of instruments we are of the opinion that the same force will bring about the fulfillment of the prediction made by Béhar in the preface to his book, *Fundamentals of Instrumentation:*

> I foresee instrument courses in the majority of technical schools, chairs of Instrumentation in universities, a nation-wide or international society . . .

It is time that one of the first-flight technical colleges established a post-graduate course in Industrial Plant Instrumentation. Such a course, correlating the necessary theory acquired by the student along proper lines, will supply the instrument designers and supervisors who will be required in the future. A supervisor must have a good technical foundation on which to build and should have experience in actual plant work in addition to knowledge of instrumentation.

One cannot over-emphasize the costly consequences of improper or inadequate instrument servicing. We know of two plants, identical in every respect except in the matter of instrument maintenance. Plant "X," where instruments are taken care of by mechanics whose primary training and interest are in other fields, is satisfied because they have attained 70% of the design capacity. Plant "Y," where the instruments are serviced by trained instrument men, operates at 140% capacity consistently. Another instance is that of a plant where costs were being proportioned on the basis of flowmeter records that were perfect circles—too perfect, in fact: the pressure-tight bearings had been "frozen" fast, but no one ever thought of equalization. An instrument in this condition is worse than no instrument at all. Some years ago we were called in on a sick boiler plant; the real trouble lay in the false information given by improperly-installed instruments. Thermocouple and resistance thermometers incorrectly installed are prolific sources of misleading results. The "double reverse" may be good football strategy but it makes a poor thermocouple hook-up, and it has happened more often than it should. It takes a trained man to trace out trouble in such a circuit. Incorrect relation of cold junction compensation and the cold junctions of multi-point indicating potentiometer systems is another place where a man who does not know the fundamentals of the circuit can be badly fooled. And, in the metering of fluid flow, many a correctly designed orifice is installed so badly that correct readings or control cannot result.

We believe that a properly supervised group of trained instrument mechanics will yield a return on their pay in excess of that normally expected from an equal amount otherwise invested.

# Cathode-ray Oscillograph Applications

Nineteenth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

## RADIO APPARATUS TESTING

### LABORATORY TESTS[1, 2]

The reputation which any make of modern receiver can build up depends largely upon the selectivity, sensitivity and fidelity of its various models, not only when new but throughout their normal life. Service technicians must be able to make adjustments on the resonance circuits when necessary, to reëstablish any of those factors that have become altered. Since even small changes in the selectivity curves produce marked changes in the fidelity, the solution is complicated unless oscillographic equipment is at hand.

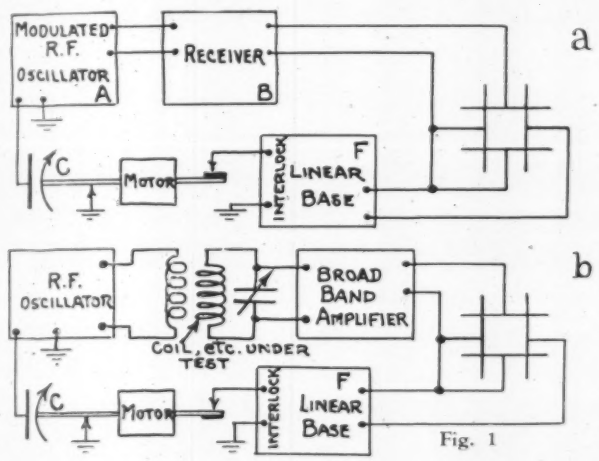



Fig. 1

### OVERALL RECEIVER TESTS

The various test methods that have been used in design laboratories differ mainly in the amount and type of auxiliary equipment required. Examples are: 1. A general check, as shown in Fig. 1a: The radio-frequency oscillator (A) is set at some frequency within the range of the receiver (B). This input signal is modulated at a definite degree with a low-frequency signal, say from 60 to 200 cycles. At the same time a motor-driven vernier capacitor (C) is connected across the main tuning condenser of (A) and varies the output frequency by approximately 15 kilocycles. This same motor also controls the interlock circuit of the time base (E) to provide a horizontal deflection of the linear type that is synchronized with the rotations of the capacitor (C). This set-up simulates the received signal and produces an oscillogram of the selectivity curve of the entire set. Variations of this arrangement will be described in later sections.

2. A similar test is obtained by modulating the output frequency of (A) by an audio frequency obtained from a beat frequency oscillator. The capacitor (C) in this case controls the frequency of the beat frequency oscillator, as in Fig. 2, over the normal audible range.

3. Other tests deal with the selectivity of the intermediate-frequency stages of the set only, but the scheme and the equipment are essentially the same.

[1] John F. Rider. The Cathode-ray Tube at Work. Rider Publishing Co., New York, 1935.

[2] Zenneck. Photographic von Stromcurven. (Shows motor-driven time base.) *Annalen der Physik & Chemie*, Vol. 69, 1899, pages 838-853.

[3] Wright. Visual Test Device (Frequency response curves). *Proceedings of the Institute of Radio Engineers*, Vol. 22, 1934, pages 89-92.

In each of these tests the cathode-ray tube has its horizontal plates connected to the synchronized time base, and its vertical plates to leads shunting the normal output load of the second detector tube as hereinafter described. It is necessary that the horizontal deflection be calibrated in terms of the side band frequency.[3]

For visual indications of the resonance curve of other r-f. circuits, or to measure capacity, inductance, or transformer characteristics a circuit similar to Fig. 1b is suggested. The effect of adjustments on any portion of the circuit under test is immediately apparent on the oscillogram.

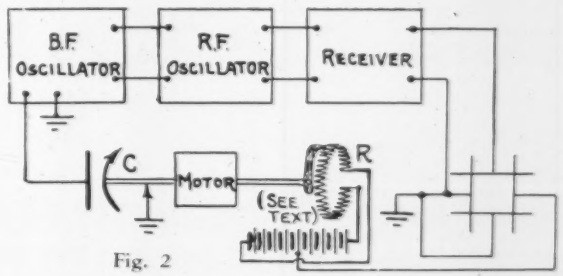



Fig. 2

In any of these systems, by moving the horizontal axis to the lower edge of the screen, the contour of the upper portion can be made to simulate the usual resonance curve. It is not difficult then to superpose two distinct curves, either by a synchronously operated switch or by manipulation. In this way the audio amplifier curve during one revolution can be compared with an overall curve during the next revolution, by the expedient of switching the beat oscillator on alternate revolutions from the audio input to the modulator input of the r-f. oscillator. The two superposed figures are readily distinguished unless they are essentially alike. Repeating such a test at several other wavelengths gives in a few minutes a complete analysis of a receiver's characteristics and so is useful in production tests.

### VIBRATING CAPACITY MODULATOR

The best-known substitute appearing recently on the market for the synchronous motor-driven capacitor used for frequency modulation is the vibrating capacitor driven by a tuned reed, resonant with the power line frequency. Such a vibration may attain amplitudes as great as one-half inch and capacity variations of 30$\mu$f. can be obtained. This capacity is varied in exact synchronism with the power line, so that the latter can be used either for the sinusoidal time base, connecting to the deflection

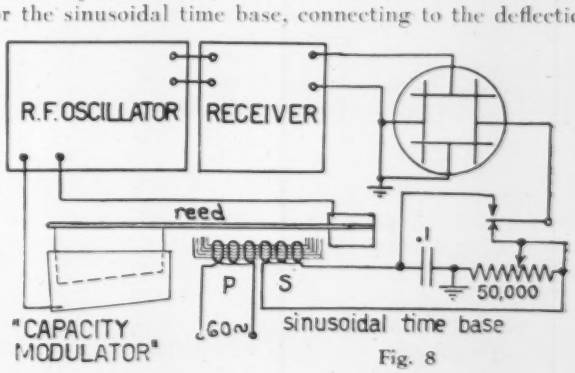



Fig. 8

plates through a suitable transformer, or else to synchronize the frequency of a linear time base if the latter is preferred, as in Fig. 8.

This arrangement may have certain advantages over the motor-driven type, as the increasing and receding capacity curves are exact duplicates, and it eliminates the need for a linear sweep, permitting less intricate and less expensive oscillographic outfits.

### VACUUM TUBE CHARACTERISTICS

Either the static or the dynamic characteristic curves of an electron tube can be delineated directly on the screen. Used as an exploring tool in analyzing operating conditions under different controlling factors, the cathode-ray tube has proved of great utility, in that it shows the whole curve directly and eliminates the slower point-by-point recording methods. In fact, a whole family of curves can be superposed together with a delineation of the two axes, each particular curve representing a particular set of operating voltages. With appropriate switching methods (often motor-driven) such a series

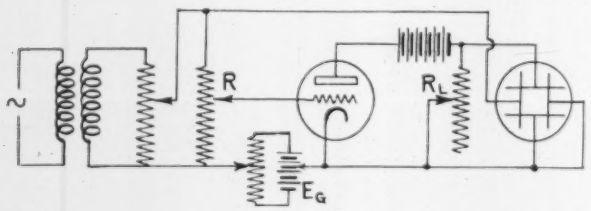



Fig. 12

can be reproduced in full in a fraction of a second and so can be repeated again and again so as to permit leisurely analysis visually or photographically. If desired, any portion of the curve can be magnified by amplification so as to show up secondary emission kinks, and other abnormalities which are not always so apparent with the step-by-step recording methods with instruments.

In general the problem is attacked by utilizing standard vacuum-tube test circuits to the oscillographic type of indicator. A typical arrangement is shown in Fig. 12. In these tests and others devised for the study of other characteristics of the tubes, the oscillograph is connected to read voltage and current as necessary.

The oscillographic indicator is particularly useful in production tests on vacuum tubes. It is inherently less accurate than a precision instrument, but operators sometimes tend to anticipate final readings of the instruments by noting the initial acceleration of the pointer, rather than awaiting the completion of its swing in order to save time. Since a cathode-ray tube records instantly, accurate results are obtained in such tests if the associated equipment is carefully designed to eliminate operating voltage variations. By using photocell alarms and opaque screen shields, audible alarms can supplement visual indications.

### FILTER CAPACITORS

High-voltage paper filter capacitors must be tested individually in production. Generally speaking, the capacitive values run within close enough limits so that a test of this characteristic is of minor importance. The ordinary test, wherein the capacitor is subjected for a short interval to a voltage sufficient to break down weak units, has been found to be inadequate in certain cases.

Investigations indicate that a more effective test is to determine the point where the power factor of the unit starts to increase rapidly as the applied a-c. voltage is increased at a constant rate. This test discloses capacitors having a high resistance and also capacitors having ionizable air bubbles within the layers, which have an important bearing on the service life. If a capacitor is used in a circuit at a voltage much higher than at at which the power factor starts to climb, it will probably have a short life. This test need not be destructive: In one case, a number of similar units were assembled in a single bank, but the individual units were used on different voltages. It was found that those units testing high in power factor could be assembled so that they were used at a lower voltage. The main advantage of such a rapid test is that the effect of variations in production processes are immediately noted.

It is desirable that manual adjustments be reduced to a single manipulation. To eliminate the need for balancing the capacitance value, a method is required wherein the capacitive variations encountered in production do not affect the result. In the circuit shown in Fig. 13, a

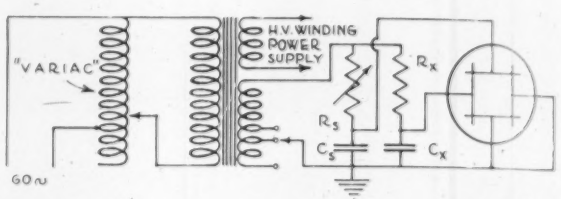



Fig. 13

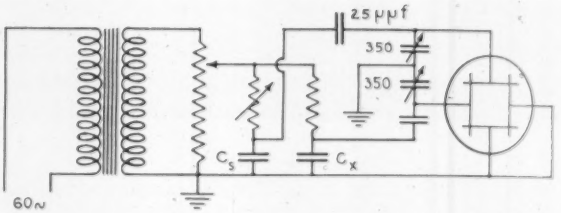



Fig. 14

straight line will appear (diagonally) across the screen when capacitors with equal phase angles are connected. The slope of this line depends upon their relative capacitances. If the power factor in one unit changes faster than that in the other, an ellipse is formed which is analyzed in the usual manner.

Inasmuch as the voltage to the deflection circuit increases at the same rate that the test voltage increases, the screen diagram would normally increase in size and might after an interval exceed the diameter of the screen. The phase difference in this case can be based on the minor axis of the ellipse, should the power factors of the capacitors differ. To simplify this determination, it is desirable to compensate for the normal increase in the size of the ellipse, due to the increase in voltage. The method used in Fig. 13 is to increase the anode voltage to the cathode-ray tube proportionally with the increase in the voltage applied to the capacitors. However, with some types of cathode-ray tube designs, it is difficult to keep the spot focused as the anode voltage is varied over a range of several to one.

The circuit shown in Fig. 13 uses a special transformer supplying power to the test circuit bridge, and the high voltage to the cathode-ray tube power-supply rectifier tube. These voltages are varied together by some device (such as a "Variac") in the primary circuit.

It also is possible to provide a capacity shunt to the deflection plate circuit which can be controlled by the same operation that controls the voltage to the bridge. One arrangement, shown in Fig. 14, decreases the voltage applied to the deflection plates at the same time that the test voltage is increased.

The actual capacity bridge used in these tests requires the usual precautions as to stray fields, losses in the

Continued on page 28

# Oscillography

Thirty-seventh instalment of "Electrical Measurements and Control." This series began in January 1934 (see editorial page of November 1933 issue). All rights reserved by the authors.

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

## 6. Electromagnetic Class

(*Continued*)

### (c) Representative Electromagnetic Oscillographs

The design and construction of a number of representative oscillographs will be made apparent from examination of Figs. 49-27 to 49-36.

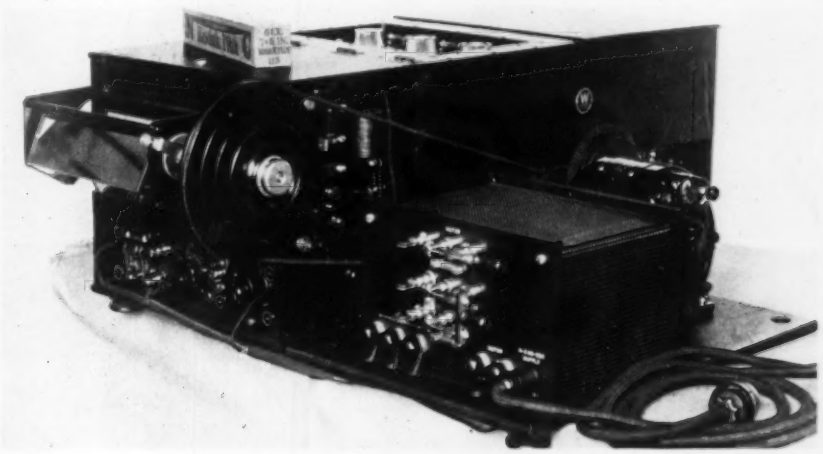


Fig. 49-27

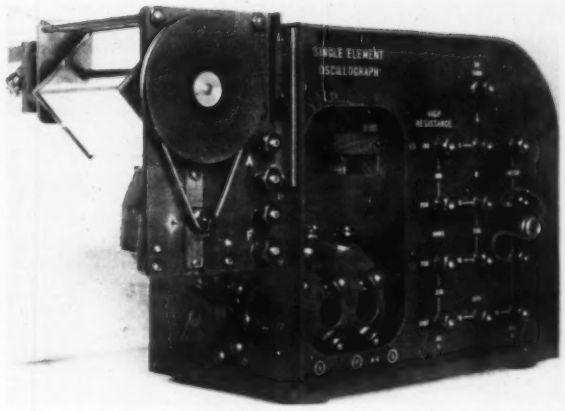
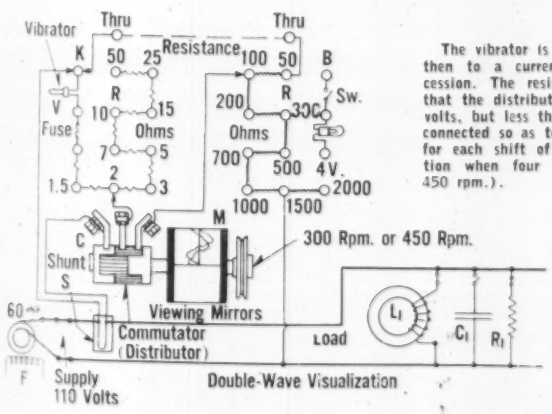



Fig. 49-28




The vibrator is connected to a voltage-recording and then to a current-recording position, in rapid succession. The resistance from 100 to 50 is used so that the distributor does not open up the whole 110 volts, but less than 10 volts. The distributor must be connected so as to shift from one circuit to the other for each shift of the mirrors (four times per revolution when four mirrors are used, rotating 300 or 450 rpm.).

Fig. 49-29

Fig. 49-27 shows the Westinghouse multi-element oscillograph; Fig. 49-28 the Westinghouse "Osiso" which has only one element. Fig. 49-29 is a diagram showing how the Osiso may be used to exhibit curves of two concurrent phenomena, a rapid switching action serving to connect the vibrator alter-

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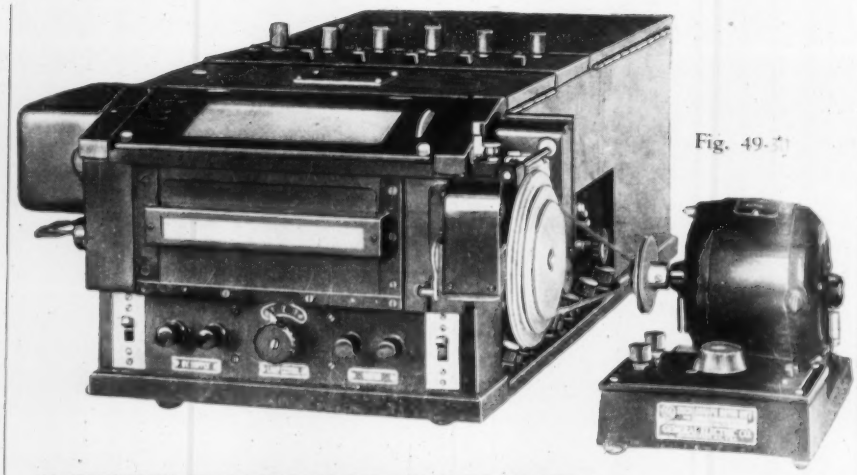

Fig. 49-31

Fig. 49-31

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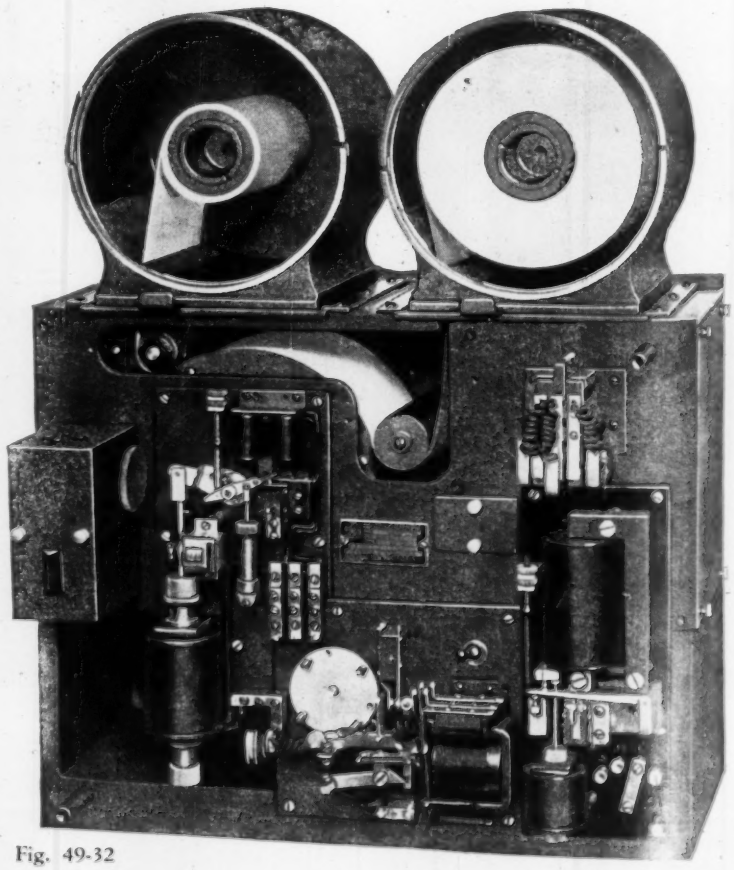


Fig. 49-32

nately to the two magnitudes under investigation and the individual curves following each other on the screen with such rapidity that, owing to the persistence of vision, the observer gains the impression of seeing the two waves simultaneously.

Fig. 49-30 is a view of the General Electric general-purpose oscillograph, designed with a view to extreme flexibility in power plant and laboratory work. The corresponding portable instrument is shown in Fig. 49-31 which illustrates the device set up for obtaining records with standard Kodak film. The G-E automatic oscillograph, Fig. 49-32, particularly adapted for permanent installation, can take as many 100 oscillograms of chance transients in a power system without attention. Its records are traced directly on sensitized paper, of which a 200-foot roll is loaded at one time. This instrument will automatically start recording within a quarter-cycle of a 60-cycle wave after the initiation of the transient of which it is desired to obtain a record. It has a particular application in the location of faults on transmission lines, and permits identifying damaged insulators within a few minutes after the occurrence of flashovers.

Fig. 49-33

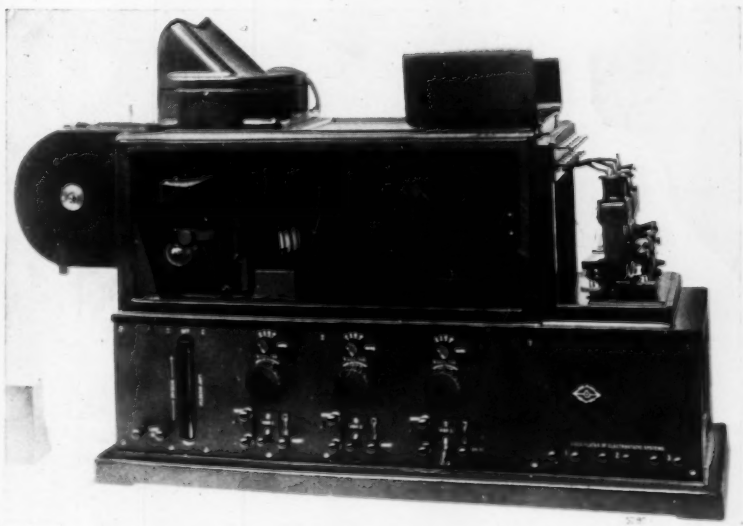
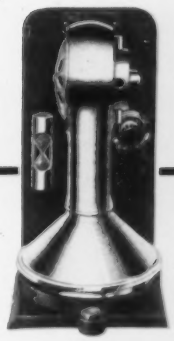


Fig. 49-34

The Siemens general-purpose oscillograph, with six elements is shown in Fig. 49-33.

Fig. 49-34 shows a Cambridge oscillograph equipped with three elements of the permanent-magnet type, one side being opened up to expose the interior arrangements and the galvanometers being drawn out at the right to bring

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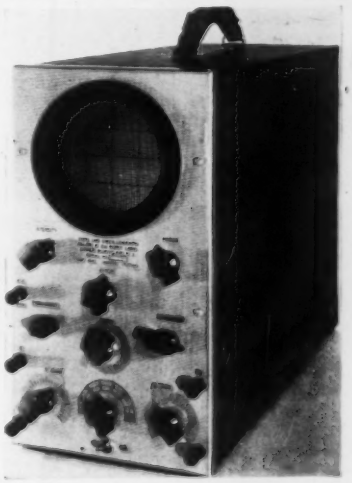

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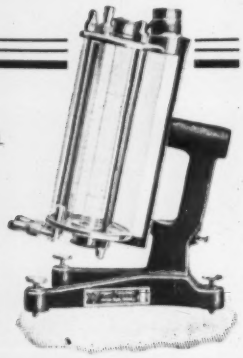

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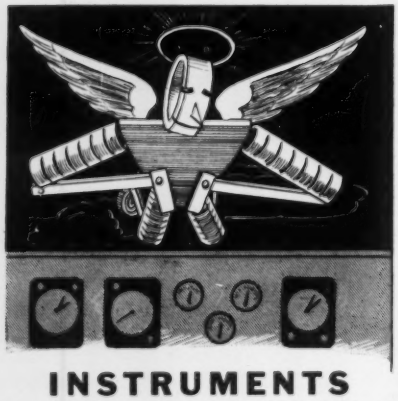

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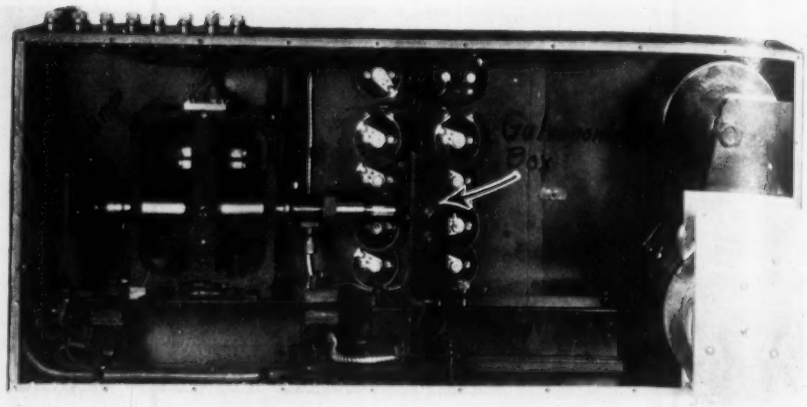

Fig. 49-35

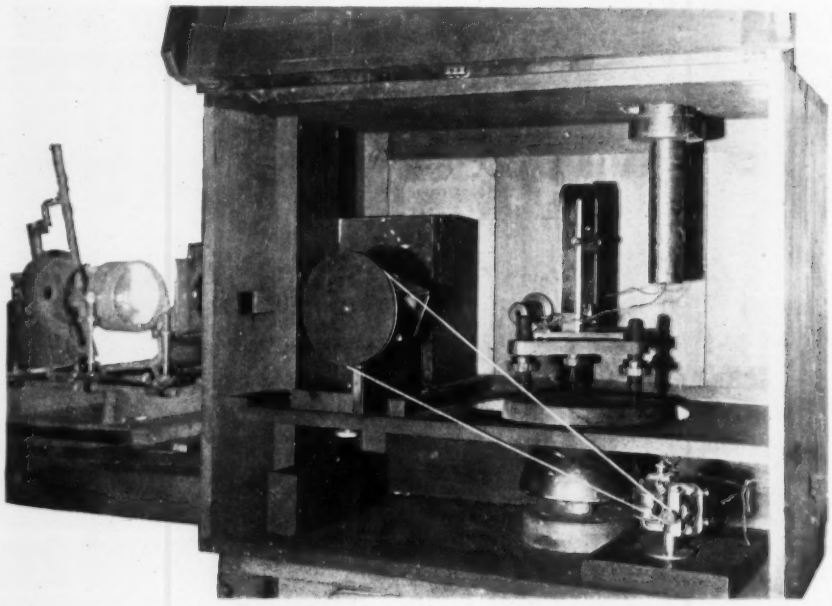

Fig. 49-36

them into view. Fig. 49-35 illustrates a complete assembly of a Cambridge twelve-filament string galvanometer, showing the lamp, the optical system, and the film or bromide-paper drums, of which there are two. The galvanometer, similar to that shown in Fig. 49-20, is contained in the box in the center. This form of oscillograph finds a particular application in geophysical prospecting by the sound-reflection method, and in military sound-ranging.

In contrast to the modern forms of oscillographs shown in the foregoing illustrations, Fig. 49-36 shows (for the first time, to the authors' knowledge) a more or less "home-made" oscillograph used in studies of the generators during installation in one of the Niagara Falls power houses in 1905. This history-making instrument was used directly connected to the high-tension circuits and, despite the handicaps of its construction, provided satisfactory record of voltage wave-forms.

*To be continued*


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# INSTRUMENTATION FORUM

## PROBLEMS — SOLUTIONS — DISCUSSIONS

### PROBLEM No. 1

(As published in November issue)

"We wish to measure the flow of liquid in our waste water lines and to secure a sample of that liquid in proportion to the amount of flow through the line.

"The liquid varies in composition, being mainly water carrying small quantities of sugar, soda, acid and other impurities.

"The flow varies from practically zero to 500 gallons per minute. (For this reason, any method employing weir boxes would not be practical.)"

### DISCUSSIONS & SOLUTIONS.

By H. J. WILMARTH

The problem as put is definitely ambiguous, and at least four basic cases must be considered.

(a) Continuous registration of the flow and continuous delivery of the proportional sample.

(b) Continuous registration of flow, and delivery at intervals long compared to the period between a flow maximum and its preceding or succeeding minimum of an accumulated proportional sample for purposes of analysis or loss estimation.

(c) A cumulative or smoothed-out registration of flow and a continuous proportional sample.

(d) A smoothed-out registration of flow and a cumulative proportional sample.

A really correct choice of instruments must depend on the type of flow (open ditch, piped under pressure, piped under vacuum, etc), the temperature of the liquid, the period between a flow maximum and the succeeding or preceding minimum, and other factors. In the discussion to follow, it is explicitly assumed that the liquid is near room temperature, piped under pressure, and that a time of at least a minute elapses between a flow maximum and the preceding or succeeding minimum. Open ditch flow can be pumped or lumped. The four cases will be discussed in the order of their simplicity, commencing with (d).

In case (d), the procedure is obviously to lead the flow into a weir box equipped with a level meter and a proportional sampler. The latter can be obtained from the Thwing Instrument Co. but must be calculated for the individual weir to be really accurate.

For case (b), I should recommend a series of conventional flowmeters, each by-passed by a magnetically or air-operated open and shut valve. The series of meters would commence with meter *A*, sufficiently sensitive to measure the smallest flow, followed by meter *B*, of such sensitivity that the maximum reading of meter *A* would come at the low end of the useful scale of *B*, and so on until the last meter was large enough to handle the maximum flow. The greater the desired accuracy of the whole system, the more meters are necessary. The by-pass valves are actuated from the meters in this way: When meter *A* reaches its maximum reading, the by-pass around it is snapped open. Similarly, as the flow increases the by-passes around *B*, *C*, etc., open as each meter reaches its maximum reading. As the flow again decreases, the by-pass across meter *C* is closed when meter *D* reaches the low end of its useful scale, and similarly those across *B* and *A* at the proper time. With this system, if the flow is within the range of meter *B*, for instance, meter *A* is automatically by-passed, and meter *C* is below its useful scale. The flow record must be assembled from the combined meter readings, but no single instrument available could have the necessary precision (0.01%). All the necessary equipment is entirely standard. The proportional sample would be taken in a weir box as above.

For case (a), I should recommend a positive displacement meter (a metering pump reversed) coupled to a cumulative reset type tachometer, or to two or three such instruments of different ranges (they are not damaged by overrunning if the proper type is procured). The friction load of the metering pump can be taken up by a low variable-speed, constant-torque motor (an ordinary squirrel-cage induction motor with the bars taken out of the armature and a suitable field resistance or auto-transformer). The proportional sample is delivered from a second—much smaller metering pump driven from the reversed main pump.

I am not familiar with all the sources of such equipment, but the De Laval Steam Turbine Co. builds metering pumps (as do the people who build gasoline dispensing pumps), and R. W. Cramer & Co. are agents for the excellent Hasler Tachometers.

The solution to case (c) is probably included in the solution of case (a) given above.

---

### SOLUTION

By V. H. HIERMEIER

Use an ordinary ratio flow control having two separate mercury U-tubes with both differential pens recording on the same chart, one pen reading from zero to 250 g.p.m., that is, to center of chart (low range—see sketch), the other in outer zone of chart, 250 to 500 g.p.m. maximum (high range).

Place both orifice plates in the main flow line (Note: This is contrary to the


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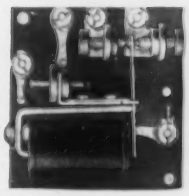
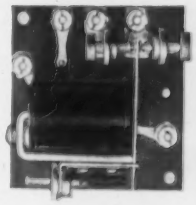


2C



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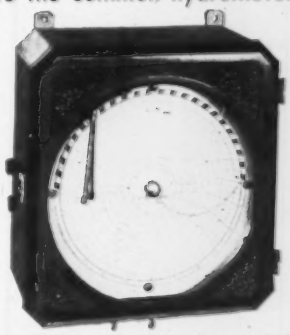

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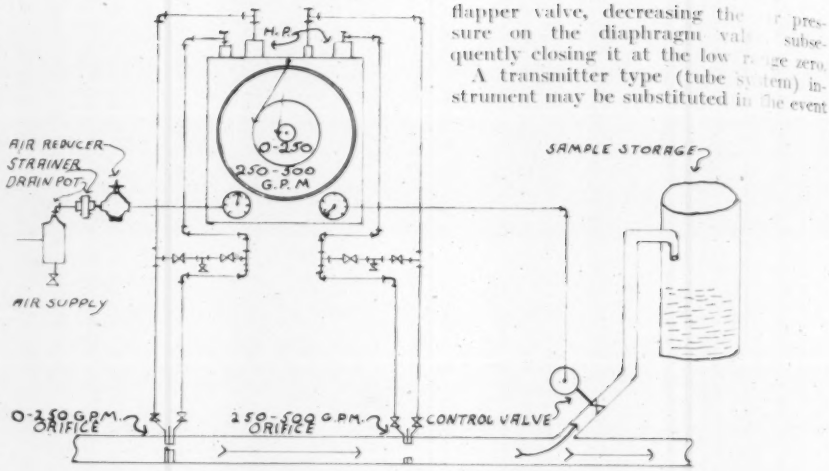



set-up for a standard ratio flow control) at least five feet from each other so that the turbulence set up by one will not affect the other. The first orifice will be of suitable size to care for the low range; the other will be larger to care for the high range. It may be necessary to increase the line size for several feet at the second orifice as there are certain limits in ratios between line and orifice sizes, to insure correct readings.

Tap a sampling line several feet below the last orifice. In this line install an air-operated, reverse-acting diaphragm valve of suitable size, determined by the amount of liquid required for sampling. The discharge of this valve to be piped to any container having ample capacity. The pressure on this vessel must be held constant so as to maintain the same amount of back pressure at all times, on the discharge of the control valve. If the back pressure be allowed to vary, the flow through the control valve will change accordingly, independently of the control instrument. Therefore, it is advised that the sampling vessel be open to the atmosphere, if possible, and that the sampling line enter near the top. So that the discharge head in the line remains the same, regardless of the level in the sampling vessel (see sketch) with zero flow the control valve is set at the closed position with zero pressure on the diaphragm valve. As the pen on the low range tends to travel out to its maximum as the flow increases, it moves the air flapper valve in the instrument so as to build air pressure on the diaphragm valve, thus opening it a corresponding amount. The pen continues to travel to its maximum or 250 g.p.m. At this point the mercury checks hold, preventing any further action outward on the low range instrument. Since the float in the high range instrument is set to start at this point, it will immediately take up the flow recording, carrying with it the flapper valve, thus continuing to build pressure on the diaphragm valve, which will in turn continue to open, sampling more liquid.

Now, as the flow decreases, the high-range pen will come to its zero (250 g.p.m.) which will tend to restore the flapper valve, thus decreasing the air pressure on the diaphragm valve and so bring it toward a closing position.

At the high-range zero the low-range pen starts its downward movement from maximum as the flow is now below 250 g.p.m. In so doing it carries with it the flapper valve, decreasing the air pressure on the diaphragm valve subsequently closing it at the low range zero.

A transmitter type (tube system) instrument may be substituted in the event that the solution contains acid in large quantities which would affect the mercury instruments.

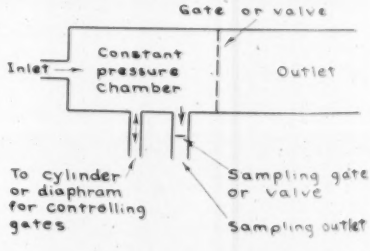
### SOLUTION

By GEORGE W. STICKLE

The sketch herewith gives a simple and effective device for measuring the flow and obtaining a sample proportional to the quantity of flow. The basic principle is a constant pressure head across the opening, maintained constant by varying the outlet area. The constant pressure head gives a constant velocity so that the volume is proportional to the outlet area.

The sampling outlet may be very small in comparison with the main outlet as long as the ratio of the two areas is maintained constant. It is possible to operate the sampling outlet at a lower pressure difference than the main outlet as long as the ratio of the pressures is maintained constant. This may be done by allowing the sampling outlet to flow into a pressure chamber maintained constant by a liquid column at a pressure less than the pressure in the main chamber.

It is necessary to have the pressure chamber and the outlet chamber free from any effect of velocity flow. This

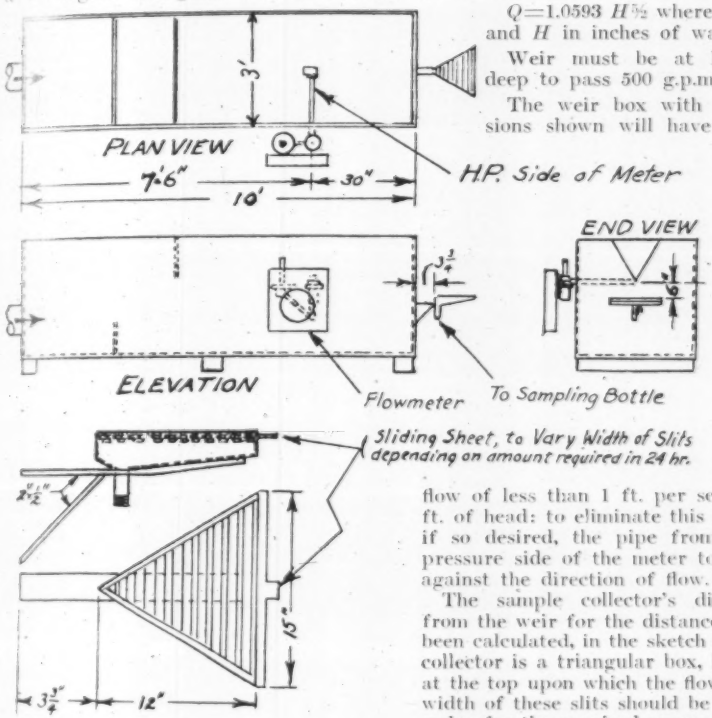



may be done by making the inlet and outlet cross-sections large in proportion to the gate area so that the maximum velocity head in the chamber is an extremely small fraction of the pressure drop across the gate.

One device for maintaining the chamber at a constant pressure is a piston that requires a constant pressure for equilibrium. Any deviation from that pressure will cause the piston to move, operating the gates and equalizing the pressure again. An alternative arrangement might use a diaphragm with electrical contacts to operate an electric motor for controlling the gates.

SOLUTION
By E. J. SCHEIBER

It was stated that a weir is hardly suitable; nevertheless, after starting with a 90 degree triangular weir in a 3′ ×




3′ × 10′ baffled box and working through, it seems the only suitable method.

$Q = 1.43\ H^{3/2}$ in ft.-sec. units (Coefficient of contraction taken into account).

$Q$ in gals. per minute $= 1.284\ H^{3/2}$ where $H$ is in inches.

Plotted on log. paper with slope of 0.4, if $Q$ is on horizontal axis and $H$ on vertical axis.

The instrument to measure the varying height of the water to be a 20" recording flowmeter: Low-pressure tap open to atmosphere and high-pressure tap on level with the vertex of the weir; also the normal mercury level in the instrument must not be above the level of the weir vertex and not more than 4" below. The high-pressure tap to be placed 30" ahead of the weir. After installation the pen-arm must be adjusted for zero when the liquid in the weir box is at the level of the weir vertex. However, instead of doing this, an equalizing line may be put between the high- and low-pressure taps.

In using the flowmeter the constant must be corrected for the mercury displacement by the water; or

$Q = 1.0593\ H^{5/2}$ where $Q$ is g.p.m. and $H$ in inches of water.

Weir must be at least 11¾" deep to pass 500 g.p.m.

The weir box with the dimensions shown will have a velocity flow of less than 1 ft. per second or ¼ ft. of head: to eliminate this small error if so desired, the pipe from the high-pressure side of the meter to be turned against the direction of flow.

The sample collector's distance out from the weir for the distance below has been calculated, in the sketch shown. The collector is a triangular box, having slits at the top upon which the flow falls. The width of these slits should be variable in order for the required amount of sample to be obtained during a specific time.

Another method of obtaining a sample in proportion to flow, although not accurate at times of small flow, would be by putting an orifice plate in the pipe carrying the liquid to the weir box: then use the differential caused by the orifice plate to operate a control valve in a line from the above pipe to the sample bottle.

DISCUSSION
By L. A. TROFIMOV

In my opinion the statement of the problem of continuous proportional sampling of a liquid is incomplete. For instance it is said "measure the flow of the liquid." Is it the rate of flow or is it a total amount at a certain interval of time? Next, "to secure a sample." How large a sample? How often should it be secured? The answers to these questions

Problem No. 3 Subject Index 8
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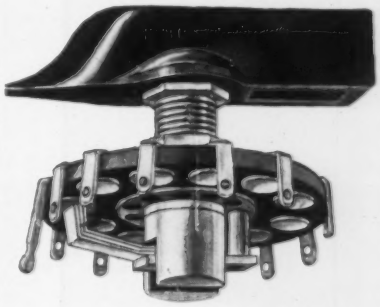

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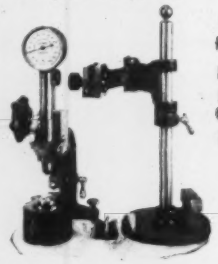

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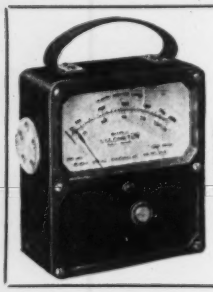

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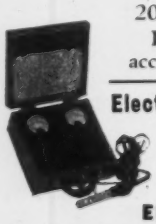

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are important because they decide what physical principle can be used for the solution.

Another trouble is that there is no definite statement of the need. Probably (but not certainly) the need is: "To know how much sugar is lost in the waste water."

In my experience in collecting information on a problem, I have found that some plan must be used in order to secure sufficient information with the least effort and in the shortest time. I suggest that the information on each problem that will be given by this Forum comply with the following plan:

First, give all the qualitative requirements for solution: such as visual indication, graphic record, signaling, continuous proportional, etc. The first two paragraphs of information on Problem 1 were of the qualitative nature.

Next give the quantitative requirements such as how large a sample, variation of the flow, accuracy of measurement, cost of the device, etc. Anything that can be expressed in numbers must be given here. The third paragraph was of the quantitative nature.

Give time-involving requirements: How often must the sample be taken? Is the device in continuous operation day and night, etc.?

Give also space requirements: How much room is available for the meter? How far is the meter from the measuring station?

And now, the human element requirements: Who is going to use the measuring device? An experienced instrument man or an inexperienced individual?

If your inquirer had given you complete information and if you had printed it systematically according to the plan outlined above, I believe that I could have sent in a possible solution.

# QUESTIONS & ANSWERS

## FOR YOUR DATA FILES

INSTRUMENTS receives a constant stream of questions, and answers most of them immediately. A selection of Q&A's, of general interest to most subscribers, and involving subjects which are NOT dealt with in readily-accessible sources, will be printed every month in this Department. Many of our immediate answers, no doubt, are incomplete; and we shall be pleased to print additional answers from readers in position to know methods and devices which have not come to our notice. One dollar will be paid for each supplementary answer printed in this Department.

### Explosion Pressures

Question No. 7 Subject Index 2.04

*"Are there any instruments on the market, suitable for recording explosion pressures, along the barrels of firearms? These are of extremely small duration (several milliseconds) and extremely high intensity (up to 60,000 lbs./in.$^2$)."*

A.—For recording powder-gas pressure, the only commercially-available instrument seems to be that of Professor Thring, Cambridge, England, further developed—and sold—by Dr. Hans Rumpff, Bonn, Germany. It utilizes the compression of a tube along its axis, transmitted by means of a concentric tube to a tiny mirror, the natural period of the system being 0.00002 sec. The recording is made photographically on a moving film, with a parallel timing record produced by 1000-cycle oscillator. (See the British Textbook of Small Arms, 1929.) Another gun pressure recorder, utilizing a somewhat similar principle, was developed by the British Ordnance Research Ass'n (see *Engineering*, Vol. 134, Aug. 25, 1932, pages 231-232). A third apparatus having this same purpose was described by J. Kirner in *Forschungsarbeiten der V.D.I.* No. 88, 1910. Kirner's apparatus photographs on a moving film the spreading of the Newtonian interference rings produced by the compression of two convex lenses touching each other. Still another recorder uses the compression of a piezoelectric crystal and a cathode-ray oscillograph. It has been made up for the proving grounds of several governments but we do not know that it is available commercially. The Petavel (English) recorder employs a piston fitted into a hole bored through the chamber wall, its outed end bearing on the center of an extremely stiff short bar spring supported at its ends. A spot on the spring, polished to a mirror finish, reflects a light beam into a revolving-drum camera. Another method, found in Glazebrook and recently proposed for cannon pressure recording by Major Marsh, Ord. Res., U.S.A., employs the effect of pressure upon the electrical conductivity of wires made of certain metals, platinum being one metal which gives a usable curve. The editor of *Instruments* (a Major, Ord. Res., U.S.A.) finds that recent commercial developments in the cathode-ray oscillograph make this instrument the preferable recording device, the initial pick-up being either a piezoelectric crystal or a piezo-resistance wire.

### SUPPLEMENTARY ANSWER

Photocell Arrangement

Question No. 2 Subject Index 5.3

By F. LOEWENBERG

Large light-sensitive surfaces can be formed by placing rectangular cells in rows and mounting them either in parallel or in series, depending upon the resistance in the external circuit. As a rule, rectangular cells come with the strip of contact metal sprayed on all four sides. If uninterrupted surfaces are required, however, these elements can also be furnished with the contact metal on two sides or on one side only.

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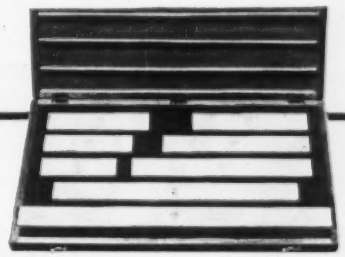

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CATHODE-RAY OSCILLOGRAPH APPLICATIONS *Continued from page 20*

capacity standards, losses due to shielding, etc. (One loss, however, is inherent with the cathode-ray tube deflection circuit—that is, the load placed on the condensers due to the ionization currents across the deflection plates. This loss may be considerable in the case of gas-focused cathode-ray tubes, and even in the case of hard tubes it should be accounted for.

### RADIO-FREQUENCY EFFICIENCY TESTS

The efficiency of many radio-frequency devices can be determined without difficulty with cathode-ray equipment. As an example, it may be desired to study the action of radio-frequency choke coils over some particular range of frequencies. For many tests a compari-

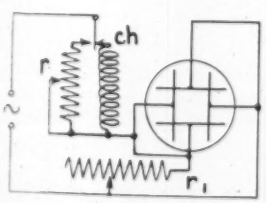


Fig. 15

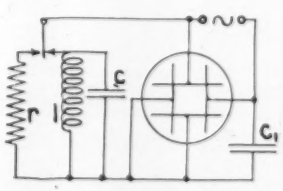


Fig. 16

son of the effectiveness of two chokes may be desired, or in other cases a choke is to be tested alone. In Fig. 15 the deflection is directly proportional to the current passing through the choke. If desired, it may be compared with the drop through a suitable resistance. It usually is desirable to make these tests on a bench rather than to try to measure the effectiveness of a particular choke in the operating circuit itself, because of the shunting effects of the deflection plate circuit to ground. In the above arrangements no extra connections are placed across the choke, to avoid changing its natural period.

### HIGH-FREQUENCY RESISTANCE

For a simple determination of the high-frequency resistance or the "Q" of a tuned circuit, the arrangement of Fig. 16 is applicable. The circuit under test, tuned to resonance, is used as the resistor part of a rotator circuit, as heretofore described. After noting the shape of the ellipse, for given conditions, the tuned circuit is replaced by a variable resistor and the same figure duplicated. If a commutator or vibrating relay (a relay connected as a buzzer) is used to make this change rapidly, the two patterns will appear superimposed and the duplication is easily made. The actual resistance can be determined from the formula $R = L/Cr$ where $L$ and $C$ are in microhenries and microfarads and $r$ is the resistance required to produce an equivalent diagram.

*To be continued*


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